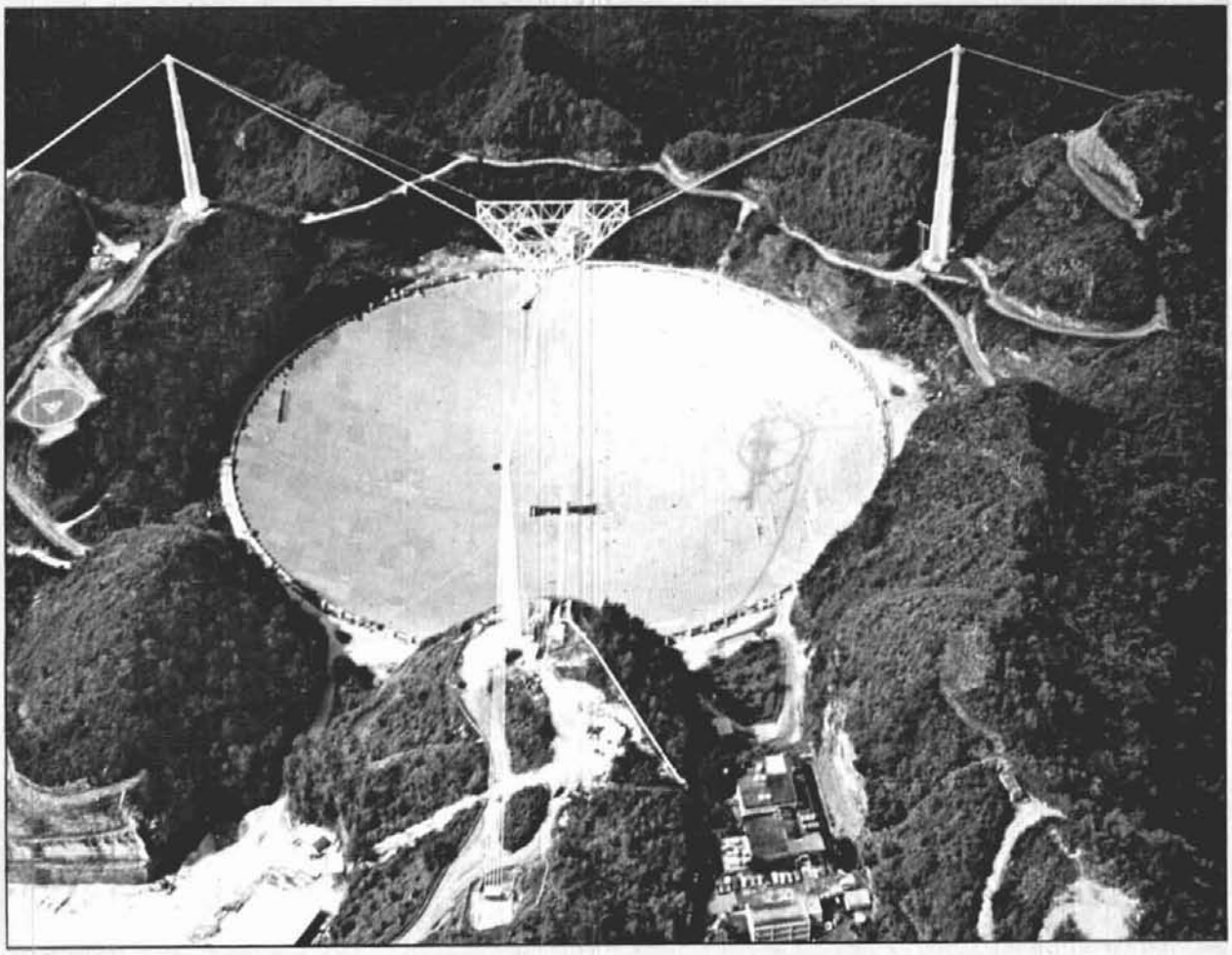
MARCH 1985 / $2.50

ham radio magazine



focus on communications technology

AMATEUR RADIO AND THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE • designing low-voltage power supplies • harmonic signal mixer • controlled vertical radiation rhombics: part one • get on 6 meters — inexpensively • fast-scan ATV amplifier • predicting solar outages • W1JR, W6SAI, KØRYW, and THE GUERRI REPORT

ICOM HF Transceiver IC-751

The Standard of Excellence in HF Base Stations

The IC-751 is the most advanced transceiver available today. It's a competition grade ham receiver, a 100KHz to 30MHz continuous tuning general coverage receiver AND a full-featured all mode solid-state ham band transmitter. The IC-751 also covers the new WARC bands, MARS frequencies, and is AMTOR compatible.

Important Standard Features. Compare these important standard features in this "top of the line" base station:

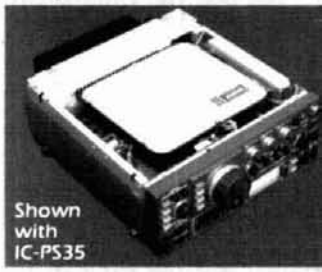
- 100KHz – 30MHz Receiver
- 105dB dynamic range
- QSK — full break-in CW
- FM Mode Standard
- High-grade FL-44A 455KHz SSB filter
- 32 tunable Memories with lithium battery backup
- 100% Duty Cycle Transmitter
- Passband Tuning
- 12V DC operation
- Adjustable AGC
- Adjustable Noise Blanker
- RIT/XIT with separate readout
- IC-HM12 Microphone with Up/Down Scan
- Continuously adjustable transmit power

Options. IC-EX310 speech synthesizer, internal IC-PS35 power supply, external IC-PS15 or IC-PS30 system supply, IC-SM8 two-cable desk mic, IC-SM6 desk mic, RC-10 external controller, and a variety of filters.

FILTER SPECIFICATIONS

Filter	Model	Center Freq. (KHz)	-6dB (KHz) Width
STANDARD FILTERS			
AM Ceramic	CFW 455 IT	455	6.0
SSB (PBT) XTAL	FL-30	9011.5	2.3
FM Filter	9M15A	9011.5	15 (-3dB)
SSB Narrow (Hygrade Crystal)	FL-44A	455	2.4
OPTIONAL FILTERS			
CW Narrow	FL-52A	455	0.500
CW Narrow	FL-53A	455	0.250
SSB Wide	FL-70	9011.5	2.8
CW Narrow	FL-32	9010.6	0.500
CW Narrow	FL-63	9010.6	0.250
AM	FL-33	9010.0	6.0

Operating From 12V, th IC-751 is also available with a optional internal AC power supply, the IC-PS35...for the winning edge in field day competition.



The IC-751 provides superio performance for all amateur radio operators...from novice to extra class. See the IC-75 at your local ICOM dealer.

Now with a ONE YEAR Warranty!

ICOM

First in Communications

ICOM America, Inc., 2380-116th Ave NE, Bellevue, WA 98004 / 3331 Towerwood Drive, Suite 307, Dallas, TX 75234

All stated specifications are approximate and subject to change without notice or obligation. All ICOM radios significantly exceed FCC regulations limiting spurious emissions. 751185

What To Look For In A Phone Patch

The best way to decide what patch is right for you is to first decide what a patch should do. A patch should:

- Give complete control to the mobile, allowing full break in operation.
- Not interfere with the normal operation of your base station. It should not require you to connect and disconnect cables (or flip switches!) every time you wish to use your radio as a normal base station.
- Not depend on volume or squelch settings of your radio. It should work the same regardless of what you do with these controls.
- You should be able to hear your base station speaker with the patch installed. Remember, you have a base station because there are mobiles. ONE OF THEM MIGHT NEED HELP.
- The patch should have standard features at no extra cost. These should include programmable toll restrict (dip switches), tone or rotary dialing, programmable patch and activity timers, and front panel indicators of channel and patch status.

ONLY SMART PATCH HAS ALL OF THE ABOVE.

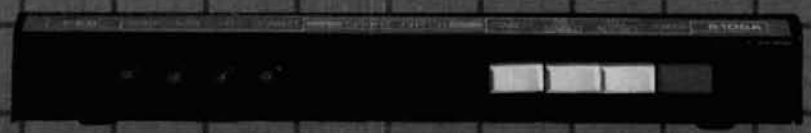
Now Mobile Operators Can Enjoy An Affordable Personal Phone Patch. . .

- Without an expensive repeater.
- Using any FM tranceiver as a base station.
- The secret is a SIMPLEX autopatch. The *SMART PATCH*.

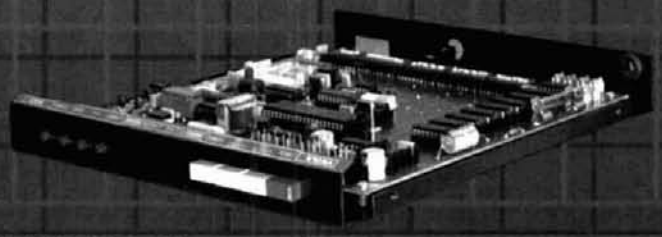
SMART PATCH Is Easy To Install

To install *SMART PATCH*, connect the multicolored computer style ribbon cable to mic audio, receiver discriminator, PTT, and power. A modular phone cord is provided for connection to your phone system. Sound simple? . . . IT IS!

With SMART PATCH You are in CONTROL

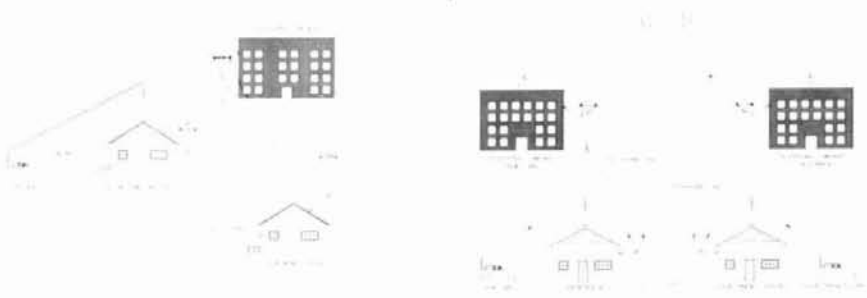


With CES 510SA Simplex Autopatch, there's no waiting for VOX circuits to drop. Simply key your transmitter to take control.



SMART PATCH is all you need to turn your base station into a personal autopatch. SMART PATCH uses the only operating system that gives the mobile complete control. Full break-in capability allows the mobile user to actually interrupt the telephone party. SMART PATCH does not interfere with the normal use of your base station. SMART PATCH works well with any FM transceiver and provides switch selectable tone or rotary dialing, toll restrict, programmable control codes, CW ID and much more.

To Take CONTROL with Smart Patch – Call 800-327-9956 Ext. 101 today.



How To Use *SMART PATCH*

Placing a call is simple. Send your access code from your mobile (example: *73). This brings up the Patch and you will hear dial tone transmitted from your base station. Since *SMART PATCH* is checking about once per second to see if you want to dial, all you have to do is key your transmitter, then dial the phone number. You will now hear the phone ring and someone answer. Since the enhanced control system of *SMART PATCH* is constantly checking to see if you wish to talk, you need to simply key your transmitter and then talk. That's right, you simply key your transmitter to interrupt the phone line. The base station automatically stops transmitting after you key your mic. *SMART PATCH* does not require any special tone equipment to control your base station. It samples very high frequency noise present at your receivers discriminator to determine if a mobile is present. No words or syllables are ever lost.

SMART PATCH Is All You Need To Automatically Patch Your Base Station To Your Phone Line.

Use *SMART PATCH* for:

- Mobile (or remote base) to phone line via Simplex base. (see fig 1.)
- Mobile to Mobile via interconnected base stations for extended range. (see fig. 2.)
- Telephone line to mobile (or remote base).
- *SMART PATCH* uses SIMPLEX BASE STATION EQUIPMENT. Use your ordinary base station. *SMART PATCH* does this without interfering with the normal use of your radio.

WARRANTY?

YES, 180 days of warranty protection. You simply can't go wrong.

An FCC type accepted coupler is available for *SMART PATCH*.

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P.O. Box 2930, Winter Park, Florida 32790
Telephone: (305) 645-0474 **Or call toll-free (800)327-9956**

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TS-430S "Digital DX-terity!"

TS-430S

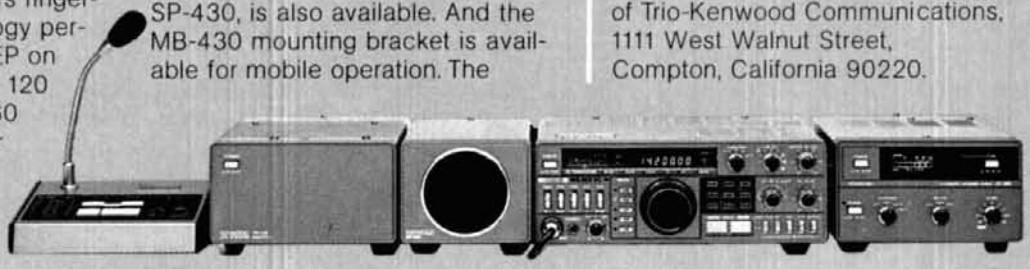
Digital DX-terity...that outstanding attribute built into every KENWOOD TS-430S that lets you QSY from band to band, frequency to frequency, and from mode to mode with the speed and ease that will give you a dominant position in DX operations.

KENWOOD'S TS-430S, a revolutionary, ultra-compact, HF transceiver has already won the hearts of radio Amateurs the world over. It covers 160-10 meters, including the new WARC bands (easily modified for HF MARS). Its high dynamic range receiver tunes from 150 kHz-30 MHz. It utilizes an innovative UP conversion PLL circuit for superior frequency stability and accuracy. Two digital VFO's allow fast split-frequency operations. A choice of USB, LSB, CW, or AM, with FM optional, are at the operators fingertips. All Solid-state technology permits inputs of 250 watts PEP on SSB, 200 watts DC on CW, 120 watts on FM (optional), or 60 watts on AM. Final amplifier protection circuits and a cooling fan are built-in.

Eight memories store frequency, mode, and band data, with Lithium battery memory back-up. Memory scan and programmable automatic band scan help speed up operations. An IF shift circuit, a tuneable notch filter, and a Narrow-Wide switch for IF filter selection help eliminate QRM. It has a built-in speech processor. A fluorescent tube digital display makes tuning easy and fast. An all-mode squelch circuit, a noise blanker, and an RF attenuator control help clean up the signal. And there's a VOX circuit, plus semi-break-in, with side-tone. All-in-all, it just could be that the expression "Digital DX-terity" is a bit of an understatement.

TS-430S Optional Accessories:
In typical KENWOOD fashion, there are plenty of optional accessories for this great HF transceiver. There is a special power supply, the PS-430. An external speaker, the SP-430, is also available. And the MB-430 mounting bracket is available for mobile operation. The AT-250 automatic antenna tuner was designed primarily with the TS-430S in mind, and for those who prefer to "roll their own," the AT-130 antenna tuner is available. The FM-430 FM unit is available for FM operations. The YK-88C (500 Hz) or YK-88CN (270 Hz) CW filters, the YK-88SN SSB filter, and the YK-88A AM filter may be easily installed for serious DX-ing. An MC-60A deluxe desk microphone, MC-80 and MC-85 communications microphones, an MC-42S mobile hand mic., and an MC-55 8-pin mobile microphone, are available, depending on your requirements. TL-922A linear amplifier (not for CW QSK), SM-220 station monitor, PC-1A phone patch, SW-2000 SWR/power meter 160~6 meter, SW100A SWR/power/volt meter 160-2m, HS-4, HS-5, HS-6, HS-7 headphones, are also available.

More information on the TS-430S is available from authorized dealers of Trio-Kenwood Communications, 1111 West Walnut Street, Compton, California 90220.



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contents

REFLECTIONS

what's wrong with Amateur Radio?

A lot of fuss is being made these days about the future of Amateur Radio. The number of new hams entering the hobby is down significantly; 10.2 percent fewer licenses were granted in 1984 than in 1983. The number of hams who upgraded in 1984 was down 30 percent from 1983, and of the hams currrently licensed, 25 percent will choose not to renew their tickets. For the first time in ten years there was, at year's end, a net loss of licensed Radio Amateurs.

What does this all mean?

Very simply, it means that Amateur Radio has some big problems.

Not all the problems are within. There's a lot of pressure from outside the hobby. Municipalities seek to limit or prohibit tower construction and control sources of possible RFI. Commercial and other interests want our spectrum space. The FCC, on one hand, has made getting the Novice license easier; on the other hand, upgrading has become more difficult — though perhaps this is no more than a temporary effect of implementing the Volunteer Examiner program.

It all adds up to an unhealthy situation. And unless all of us — each and every ham in the United States — gets involved, very soon, Amateur Radio as we know it *may cease to exist* within the next ten years.

Some might say this is an overly provocative statement, and that I'm seriously exaggerating the situation.

I don't think so.

A few days ago I read an editorial by Al Dorhoffer, K2EEK, in the February, 1985, issue of *CQ*, and spoke with Al by phone later.

While *ham radio* and *CQ* address two uniquely different segments of Amateur Radio, our futures are irrevocably linked to the future of this hobby. In his editorial, Al pointed out that we need to involve our children in Amateur Radio. There's a dual meaning here, because by "our children," Al means both our own offspring and children in general. Before you go out and rail against what is or isn't being done by everybody else, let me ask you to look at your own household. On close examination, I think you'll find some interesting information there.

If you do have kids at home, are they hams? (If they are, congratulations. You can skip the next paragraph.)

If they aren't hams, why aren't they? Have you done everything possible to interest them in Amateur Radio? Or have you bored them with statistics and failed to show them how much fun Amateur Radio really can be?

Watching Mom or Dad on the air isn't the answer.

Hands-on experience is.

Studies in group dynamics show that in any group, 90 percent of the work is done by 10 percent of the people involved. If you're sitting back waiting for somebody else to interest *your* kids — or your neighbor's — in Amateur Radio, you can sit back and watch Amateur Radio wither away. All across the country there are local pockets of enthusiasm that seem to turn out the majority of new hams year after year. If your area isn't one of these, what are you doing to make it so?

Examining the latest figures on VEC exams given nationwide, I was discouraged to find that while some areas are being well served, with aggressive recruiting programs and regularly scheduled examinations, others were still waiting for their first exam sessions.

Another point K2EEK mentioned must be emphasized: Amateur Radio is not a private club. Once we've attracted new hams — whether they're young people or adults — we owe them all the nurturing, all the help, we can give them. When questions are asked, help should be given. Several months ago we received a letter from an irate newcomer to the hobby. An eager Novice, he'd joined a local ham club only to be totally ignored by most of the membership. Meetings were spent discussing ways to beat the cable company and how so-and-so was such a ding-a-ling. Nobody was interested in helping him enter the mainstream of Amateur Radio.

On the way to visit relatives over Christmas, I was talking with a friend on a repeater in central Pennsylvania. After we signed, two other hams got on and proceeded to have a donnybrook. If I'd been trying to demonstrate the wonders of Amateur Radio to a friend at the time, I would have been terribly embarrassed. What would *he* have thought?

The bottom line is that before we go blaming anyone else for the problems in Amateur Radio, we have to look at ourselves first. If you have kids at home, and they're not hams, *how come*? If your club doesn't have any young members, *why not*? And if you're quarrelling on the air, *what are you telling prospective hams about Amateur Radio*?

It's up to *us* to make sure that Amateur Radio survives. If we do nothing but blame everyone else, it won't — it's really that simple.

Physician, heal thyself.

J. Craig Clark, Jr., N1ACH
Assistant Publisher

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300 WATT ANTENNA TUNER HAS SWR/WATTMETER, ANTENNA SWITCH, BALUN. MATCHES VIRTUALLY EVERYTHING FROM 1.8 TO 30 MHz.

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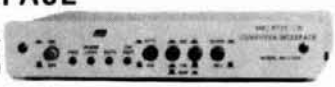

Free MFJ RTTY/ASCII/CW software on tape and cable for VIC-20 or C-64. Send and receive computerized RTTY/ASCII/CW with nearly any personal computer (VIC-20, Apple, TRS-80C, Atari, TI-99, Commodore 64, etc.). Use Kantronics or most other RTTY/CW software. Copies both mark and space, any shift (including 170, 425, 850 Hz) and any speed (5-100 WPM RTTY/CW, 300 baud ASCII). Sharp 8 pole active filter for CW and 170 Hz shift. Sends 170, 850 Hz shift. Normal/reverse switch eliminates retuning. Automatic noise limiter. Kantronics compatible socket plus exclusive general purpose socket. 8x1¼x6 in. 12-15 VDC or 110 VAC with adapter, MFJ-1312, $9.95.

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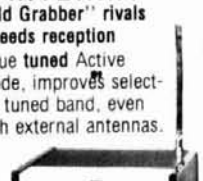

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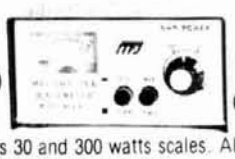

Low cost VHF SWR/Wattmeter! Read SWR (14 to 170 MHz) and forward/reflected power at 2 meters. Has 30 and 300 watts scales. Also read relative field strength. 4x2x3 in.

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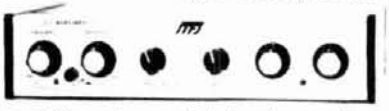
MFJ-752B **$99.95**



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RS20M	16	20	$109
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MODEL	BAND	PRE-AMP.	INPUT	OUTPUT	DC PWR	SALE PRICE
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B23S	2M	No	2W	30W	5A	$79
B215	2M	Yes	2W	150W	22A	$259
B108	2M	Yes	10W	80W	10A	$159
B1016	2M	Yes	10W	160W	20A	$249
B3016	2M	Yes	30W	160W	17A	$199
C22A	220	Yes	2W	20W	5A	$89
C106	220	Yes	10W	60W	10A	$179
C1012	220	Yes	10W	120W	20A	$259
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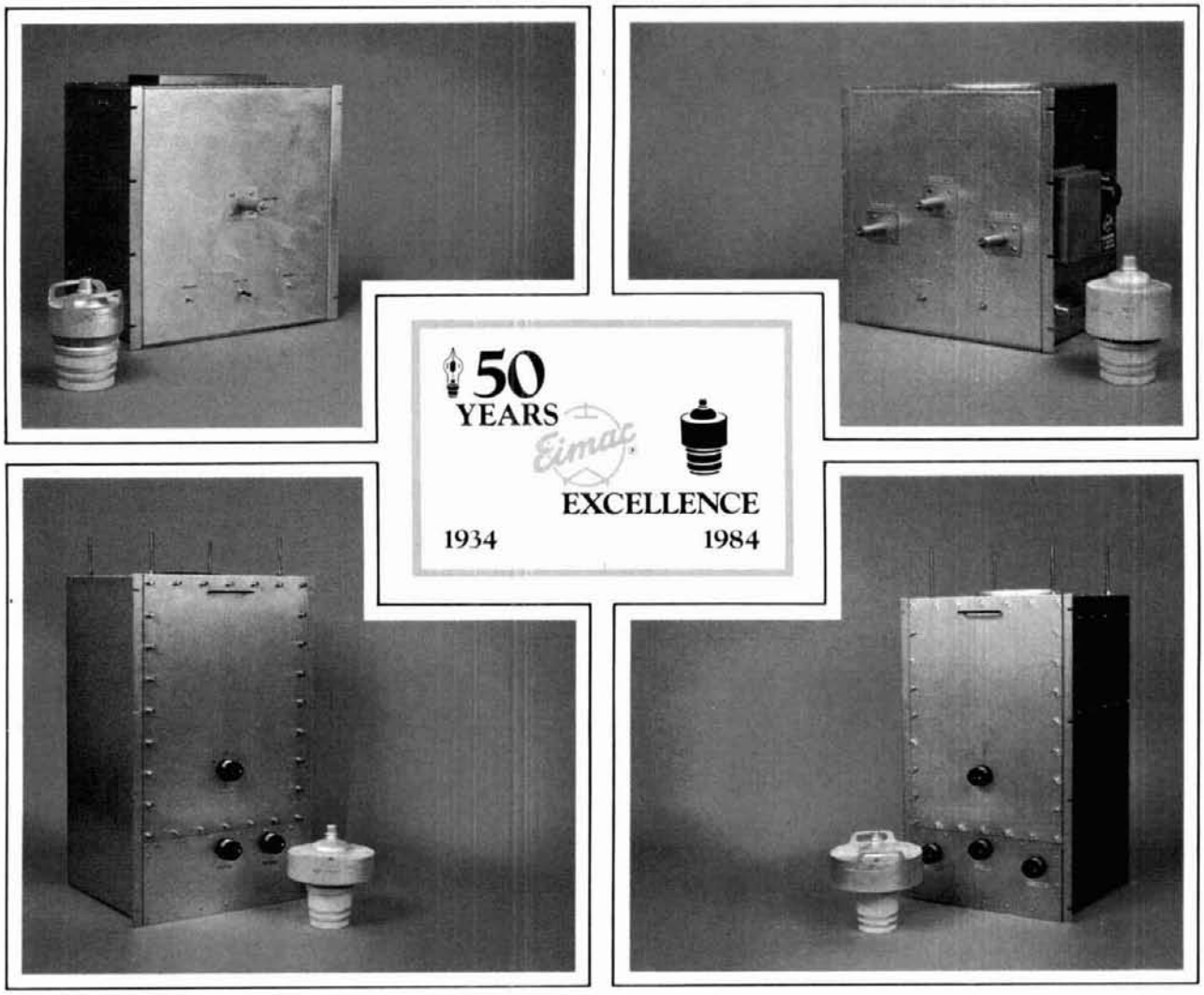

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SENATE SUPPORT FOR PRB-1, ARRL'S PETITION REQUESTING FCC PREEMPTION of state and local restriction of Amateur antennas and activities, is being sought by Senator Barry Goldwater, K7UGA. In his Senate Resolution 36 he states it is the "sense of the Senate" that the FCC affirm that state and local governments must not pass laws that "discriminate unreasonably among Amateur Radio Antennas..." or "have the effect of prohibiting or frustrating the transmission or reception of Amateur Radio communications...." A parallel proposal, Senate Resolution 35, extends the same protection to TVRO satellite antennas.

If The Senate Does Vote In Favor Of Resolution 36 it will provide a big boost for PRB-1, even though it is not binding on the FCC, Amateurs everywhere should contact their senators immediately to urge them to support Senate Resolution 36—and also Senate Bill 66, Goldwater's new bill making intentional interference to any radio service a federal crime.

AMATEUR VHF/UHF FREQUENCY COORDINATION SHOULD BE A NATIONWIDE, organized effort, the FCC has proposed in a far-reaching NPRM that's just been released. An increasing number of requests from Amateurs for FCC assistance in settling repeater conflicts, plus the general awareness that the problem will continue to worsen with ever-increasing VHF/UHF band usage, is behind the FCC's proposal. One example is the recent case of a New England repeater operator who sued another repeater group and the council that coordinated them on his machine's frequency. That conflict was resolved only with the intervention of top ARRL officials, and the second machine is now looking for another frequency.

Role Model For An Amateur Radio National Volunteer Coordinator is the land mobile industry, where industry trade groups have set up a coordination effort that is highly respected and considered very effective. For Amateur Radio, the ARRL is the logical—if not the only—organization capable of taking on an effort of such magnitude. However, in the past the League has steadfastly maintained its distance from coordination efforts, limiting its involvement to band plan generation and publishing its repeater directory. In its 1985-86 Repeater Directory, however, the League does plan to indicate which repeaters are "coordinated" and which are not. The actual coordination has been done by state or regional councils or individual volunteer coordinators, with varying degrees of success.

The Comment Period On The National Coordinator Proposal, designated PR Docket 85-22, has been made unusually long. Comments are not due until July 1, while Reply Comments can be submitted until September 30.

The Midwest Meeting To Discuss 20 kHz Spacing On 2 Meters' High End was considered very successful, despite record-breaking cold over the January 19-20 weekend. About 40 people—representing Ohio, Indiana, Kentucky, Wisconsin, Ontario, and of course Michigan, whose decision to shift to 20 kHz next year had precipitated the meeting—were present. Tone of the ARRL-sponsored session was generally positive, but with little apparent enthusiasm outside of Michigan for the change. The meeting lasted over five hours, and when it ended the Michigan representatives agreed to take the matter back to their council for further discussion. A followup meeting may take place at the Dayton Hamvention in April.

Texas' Decision Whether Or Not To Adopt 20 kHz Spacing was expected at the February 16 meeting of the Texas VHF FM Society. Nebraska Coordinator WAØWRI reports his state is not considering a shift to 20 kHz spacing, contradicting February Presstop. He also says there's little support for a move in Iowa, and he expects it to be voted down in Kansas.

STIMULATING INTEREST IN AND GROWTH FOR AMATEUR RADIO was to be the subject of a closed, all-day meeting January 31 just before the Miami Tropical Hamboree. Initial idea for the meeting came from Mike Lamb, N7ML, of AEA, and it was picked up by many other Amateur Radio manufacturers, distributors, and publishers. Focus of the discussion was to be on how Amateur Radio, whose growth has stagnated in recent years, can be revitalized, and what can be done to make the ARRL's growth targets for the next few years possible. A report on this crucial meeting will appear in ham radio's April issue.

A VEC NO LONGER HAS TO ADVISE THE FCC FIELD OFFICE OF FORTHCOMING EXAMS under an order adopted by the Commission in late January. It should be effective before this reaches print. Another rules relaxation to simplify VE paperwork, also adopted, is due shortly.

The 30-Day Wait Before Taking A Failed Exam May Be Dropped altogether under a Notice of Proposed Rule Making released in January. The Commission's proposal, PR Docket 85-21, would remove the mandatory delay from the exam rules; an applicant, if he wished and the VEs permitted, could retake a failed exam the same day he flunked it! The only limitation would be that the VEs would have to give him a different set of questions for the second attempt. In addition, under the proposed rules change a VEC could, if it wished, set a waiting period of its own choosing.

Comments On PR Docket 85-21 Will Be Due About April 1, with Reply Comments two weeks later. (The exact dates had not yet been set at press time.)

IMPLEMENTATION OF WARC CHANGES IN MICROWAVE AMATEUR BANDS have been proposed in yet another FCC NPRM. The most significant change in the proposal is probably the loss of 25 MHz at the bottom of the 21-cm band, making it 1240-1300 MHz instead of 1215-1300 MHz.

Comments On The WARC Microwave Implementation Proposal, PR Docket 85-23, will be due about the first of April. Reply Comments will be due in mid-April.

new trends in communication technologies: radio astronomy and the search for extraterrestrial intelligence

"Man's first step toward maturity
may be to contact life beyond the solar system."

—Bernard M. Oliver

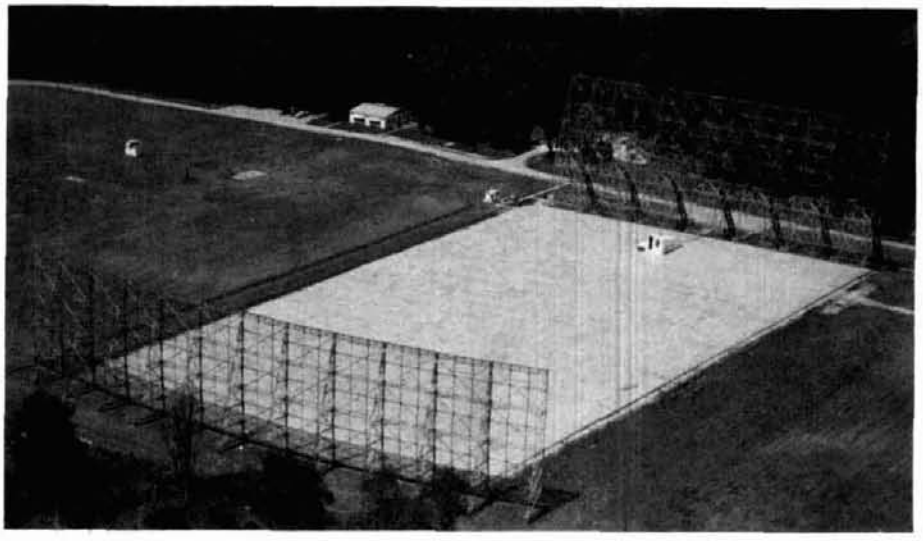

fig. 1. This radio telescope — larger than three football fields — allows for the detection of thousands of radio sources extending to distances of 10 billion light-years (1 light-year = 6 × 10^{12} miles). (Photo courtesy of Ohio State University Radio Observatory.)

If you're looking for a new technical challenge, you may find SETI, the Search for Extraterrestrial Intelligence, to be just the frontier you've been seeking. With today's microwave technology, it is possible to communicate anywhere within our galaxy. And although radio astronomy is still a relatively young science*, Amateur Radio operators have access to most of the state-of-the-art components found in a professional radio astronomy center, with the possible exception of the very large antennas. Because nobody knows what the first extraterrestrial signal will be like, there is ample room for ham ingenuity. After all, if hams were to be the first to communicate with extraterrestrials, it wouldn't be the first time a major scientific breakthrough had been made by hams — remember, not too long ago hams discovered the ionosphere.[1]

For several years I have been contemplating the construction of a system that would allow the reception of intelligent information generated by a hypothetical 1-Gigawatt EIRP (real power times antenna gain) transmitter located approximately 25 light-years away. I prepared this article in order to share some of the knowledge gained during this process and to provide a comprehensive overview of recent progress in radio astronomy (including SETI) and to assess what Amateurs can do with even limited resources.

*Unlike other events in science, the birth of radio astronomy can be traced precisely — to the early 1930's when Carl B. Jansky, a Bell Telephone radio engineer, performed antenna noise studies for long-range communications at the wavelength of 14.6 meters. With these studies, Jansky proved that extraterrestrial radiation can be received. Jansky's experiments were followed, in the late 1930's, by Grote Reber, W9GFZ, an amateur astronomer who designed and built the first parabolic radiotelescope and performed a survey of the galaxy at the wavelength of 1.9 meters.

By Cornell Drentea, WB3JZO, 7140 Colorado Avenue North, Brooklyn Park, Minnesota 55429

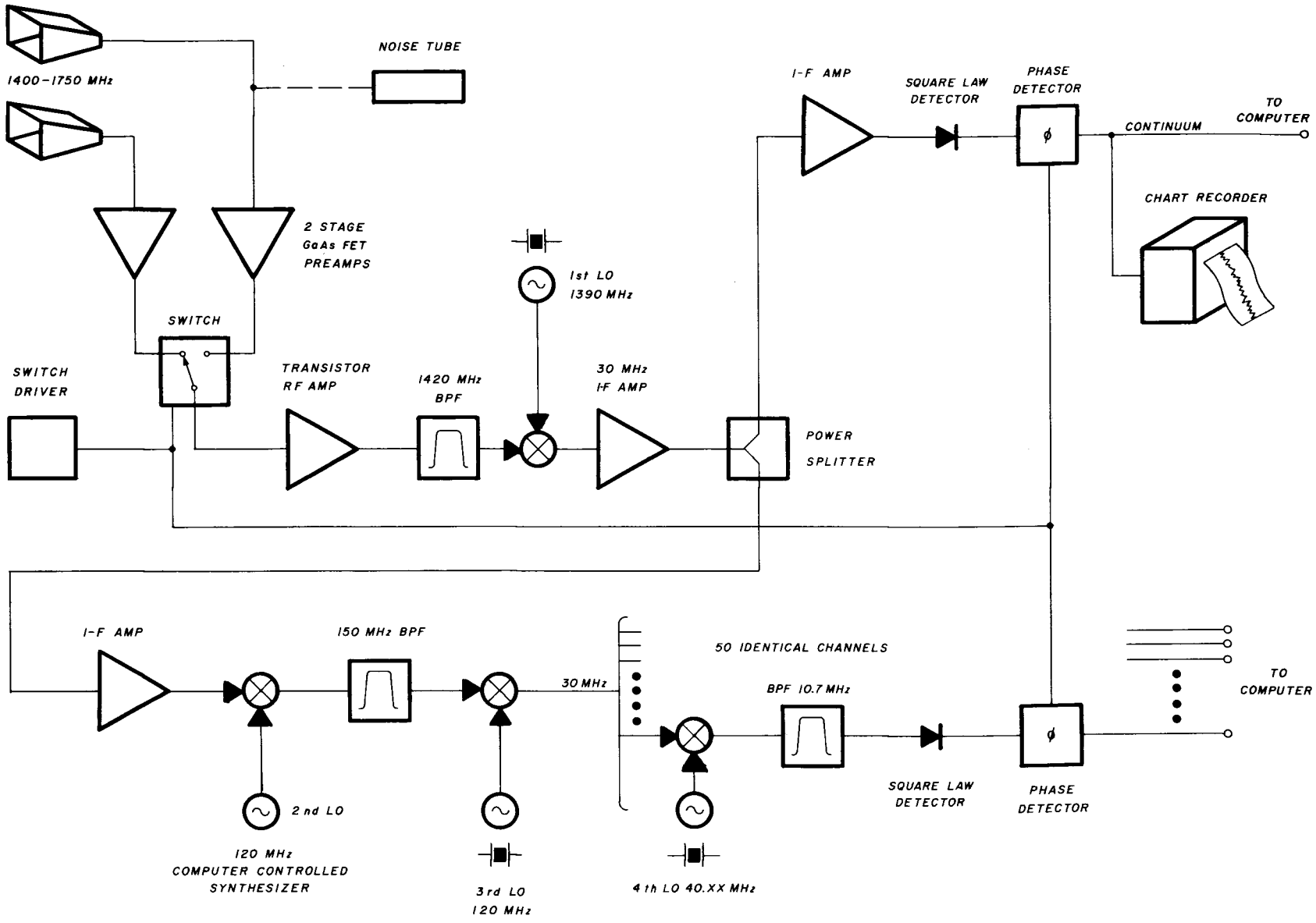

fig. 1B. Block diagram of the Ohio State University radio telescope configured for SETI. The system covers an instantaneous bandwidth of 500 kHz through a bank of 50-channel IF filters at 10.7 MHz (individual filter bandwidth is 10 kHz). (*Courtesy of Ohio State University Radio Observatory.*)

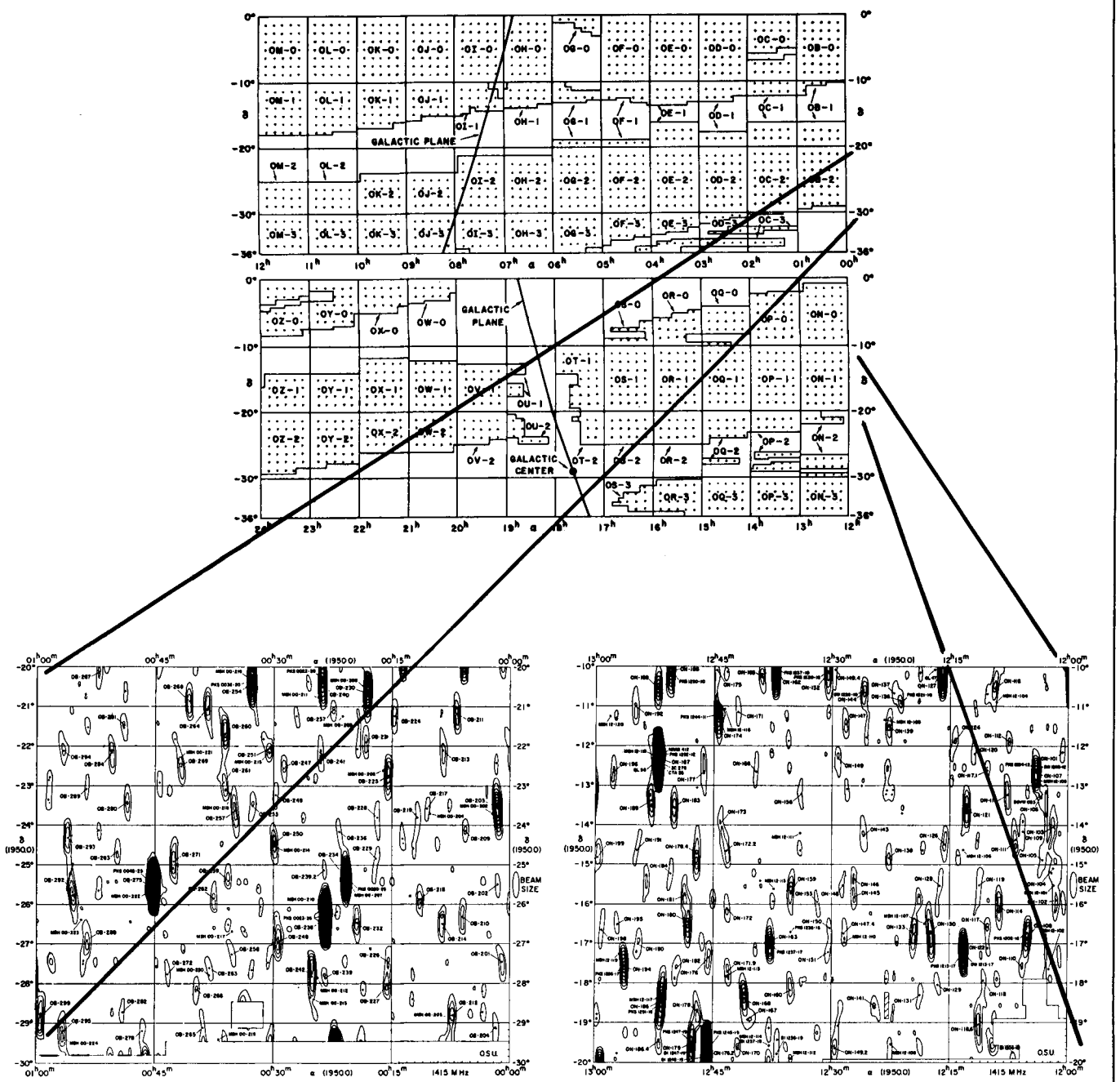

fig. 2. Master map of an Ohio University radiometer search. Maps below illustrate details of two sections indicated above. (*Courtesy of Ohio State University Radio Observatory.*)

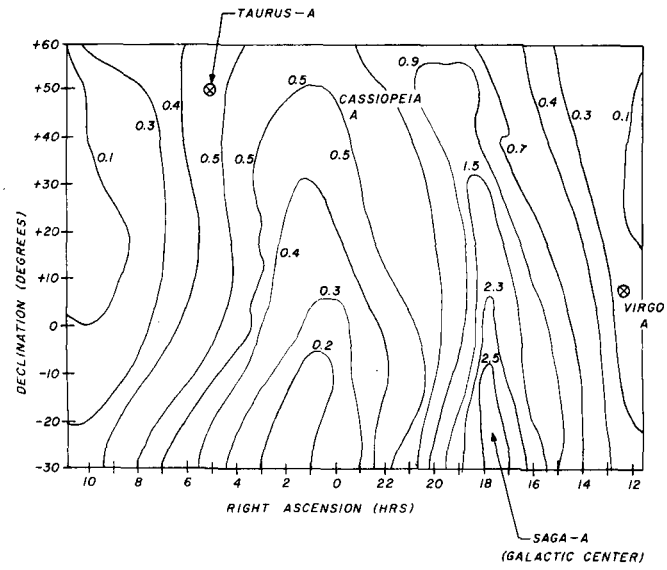

fig. 3. A map of the radio sky obtained with a simple amateur radiometer. Because of the antenna's low resolution, discrete radio sources appear as a set of signal gradient lines resembling a surveyor's map.

conventional radio astronomy

There are two current trends in radio astronomy. The first, and by far most popular, involves the study of wide-band noise generated by powerful sources within our galaxy or in other galaxies. The second, which occupies only a small fraction of the total activity, employs extremely narrow bandwidth receivers designed for the detection of intelligent monochromatic signals in the microwave regions of the frequency spectrum where the level of intergalactic noise is lowest.

Within the context of the first trend, it is relatively easy for an Amateur to build a radiometer receiver intended for casual observations of very strong radio sources. Because of the uniform distribution of wide-band noise over the receiver's bandwidth, no particular attention to local oscillator stability is required. There would likewise be no need for precise tuning to compensate for the Doppler shift in the incoming signals caused by Earth's rotation and by the relative motion between the observed celestial object and our own solar system.

Professional radiometers employ giant steerable antenna arrays that allow for the detection of natural radio sources located at great distances from Earth. A continuum survey of the sky was made by the Ohio University Radio Observatory, using the installation shown in **fig. 1A** and **1B**. The receiver employed a liquid nitrogen-cooled parametric amplifier with a calculated system temperature of 95 degrees K. The bandwidth was 8 MHz and the output was integrated over a 10-second period. Concurrent recording was performed after processing the data through IBM 7094 and 1620 computers. The entire system was synchronized with a sidereal clock accurate to within 0.05 second. Results have been plotted in maps of the region surveyed as shown in **fig. 2**. In its search of almost the entire sky, from −36 to +63 degrees, the Ohio State project found 20,000 radio sources.

While such performance cannot be duplicated by the backyard radio astronomer, remarkable results can be obtained with relatively modest installations. An Amateur radiometer is usually a high-gain VHF/UHF superheterodyne receiver that features simple amplitude modulation detection followed by a DC amplifier equipped with an integrator. The output transducer can take the form of a conventional chart recorder or some other measuring device, or can be an analog-to-digital (A/D) converter connected to a microcomputer using a dot matrix printer for the output. The format would be digitized flux samples (values from 0V to 9V) at, for example, 1-second intervals printed out in 60-second columns for a total of 1 hour of information per page. With such a receiver and a multi-element beam antenna — and with considerable skill and patience — a serious Amateur can map the radio sky in a short time.

The methodology employed involves pointing the antenna at a known celestial location and then relying on the Earth's rotation to bring in the various natural radio sources. This requires knowing celestial coordinates and times as well as converting the recorded information and antenna position into the right ascension and declination values in order to plot the signal onto a celestial map that would resemble the actual sky (see **fig. 3**).

A typical multi-element beam antenna with a major lobe beamwidth between the half power points of approximately 30 degrees would allow a natural radio source to pass through its beam in approximately two hours (the apparent rate of movement of a celestial object is 15 degrees per hour at the equator). This in turn would be sufficient to allow for the reception of strong Milky Way sources such as Cygnus A, located approximately 500 light-years away, and Cassiopeia A, located approximately 200 light-years away, regardless of the system's bandwidth or operating frequency.

very-long-baseline interferometry (VLBI)

In order to increase the resolution of a simple radiometer so that much smaller or more distant objects can be distinguished, increased antenna directivity is required. This, in turn, dictates large physical installations, which are difficult and costly to build. To overcome this problem, a new kind of a receiving system, the interferometer,

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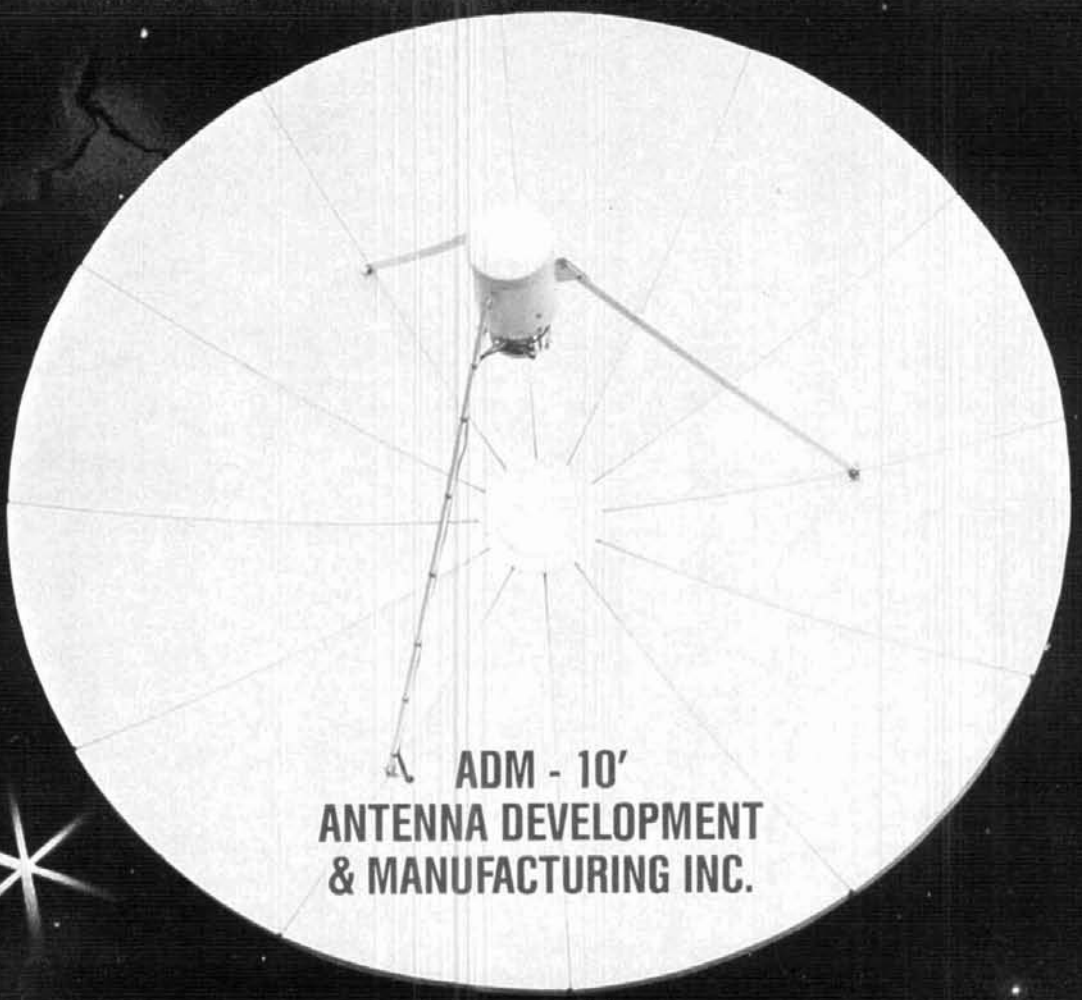

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was developed. This system uses a pair of antennas and transmission lines separated by a specific horizontal distance (i.e., the "baseline") extended to an even multiple of the operating wavelength, preferably more than fifteen wavelengths. The system is usually configured in an east-west orientation. The idea is that a radio signal from a celestial source arrives at two antennas successively, in phase and out of phase, because of Doppler shifts caused by the Earth's rotation. If the two signals are combined through a zero-degree RF combiner, a fringe pattern of interference results, breaking up the large central antenna lobe into a variety of smaller ones. The longer the baseline, the narrower the lobe, or "aperture" (see **fig. 4**).

Very-long-baseline interferometry (VLBI) is possible today through observations made simultaneously by radio telescopes thousands of miles apart, with local oscillators and subsequently recorded data synchronized within a fraction of a microsecond through the use of atomic clocks. This eliminates the need for running coaxial cables from the antenna sites to the central location for processing, and the result can be a beamwidth of 0.0001 arc-second, which is far superior to optical telescopes previously used. For comparison, the 200-inch optical telescope on Palomar Mountain has a theoretical resolution of 0.023 arc-second. Yet because of the effects of atmospheric phenomena, its practical resolution is only about 1.0 arc-second. A block diagram of a VLBI system is shown in **fig. 5**.

Using a special hybrid mapping technique and several radio telescopes located in California, Texas, West Virginia, Massachusetts, and West Germany, astronomers have recently made some exciting new discoveries. The first quasar (3C 147) ever observed with this method has been effectively mapped; it is located some seven billion light-years away. The resolution was in the order of 0.01 arc-second — a considerable improvement over the resolution of the Palomar optical telescope, which detects 3C 147 as no more than a faint star. The radio picture revealed a jet 5000 light-years long emanating from a bright core. Another quasar (3C 273) was observed with a resolution of 0.001 arc-second; its observation recorded matter being ejected from a bright core traveling at nearly the speed of light, a previously suspected phenomenon called *superluminal motion*. (Superluminal motion has been found in two additional quasars and in a distant galaxy as well.)

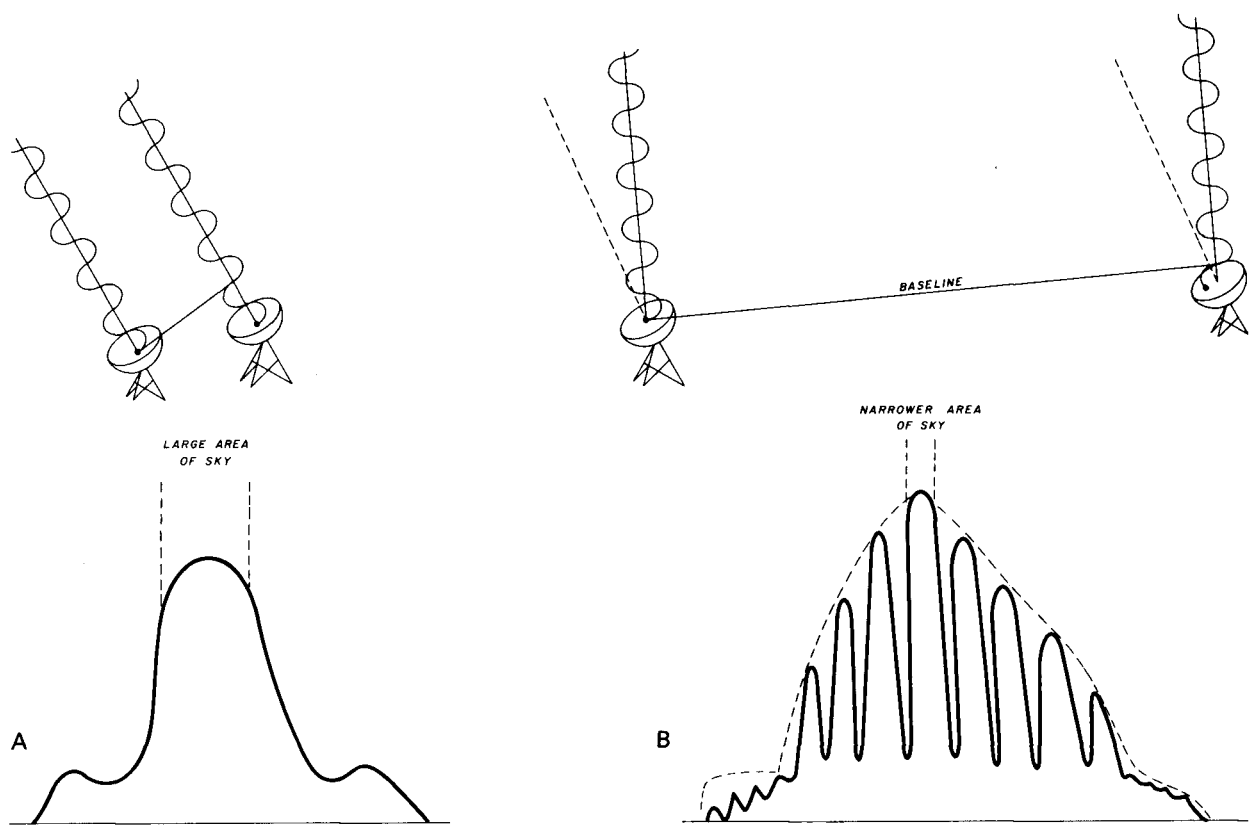

fig. 4. The principle of the radio interferometer telescope. At (A), the signal received by an antenna system peaks over a broad area of the sky. At (B), the signal received by interfering signals from each antenna peaks over a narrower area of the sky.

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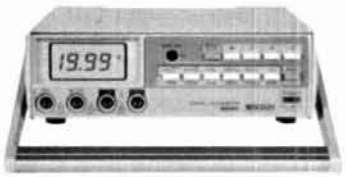

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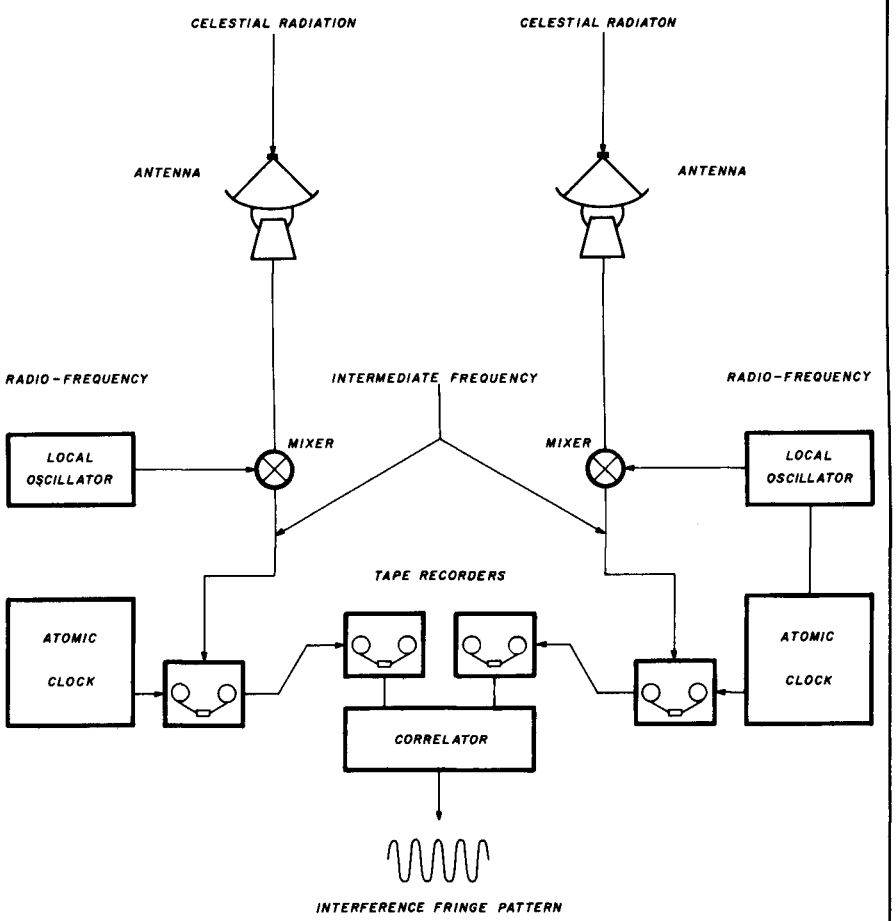

fig. 5. Very-long-baseline interferometry (VLBI) eliminates the need for the antennas to be (hard) connected to a single receiver. Atomic clocks allow the synchronization of separate local oscillators at all locations to a fraction of a microsecond. The final correlation of the data is achieved later at a central processor by playing back and synchronizing the wide-band video information.

We will now turn not to the probability of life elsewhere — the subject has already been discussed in great detail — but to the possibility of receiving intelligent transmissions (see **fig. 7**). Assume that extraterrestrial life exists. Assume also that the only reason we haven't yet discovered extraterrestrial life is because radio technology has only recently matured sufficiently to allow low noise amplifiers and high resolution microwave synthesizers to be used.

To make the best possible effort in searching for extraterrestrial signals, we would have to cover the microwave frequency range between 10^9 to 10^{10} Hz (1-10 GHz) in narrow steps of, say, 1 Hz. (Ultra-narrow bandwidths are necessary to obtain the best signal-to-noise ratios in SETI.) This means 9×10^9 steps. If we would spend one second per frequency step, and search with one thousand frequencies at once, thereby reducing the number of steps to 9×10^6, it would take approximately three months to search the sky in a single direction. The other condition for our nearly ideal search would be very narrow antenna beamwidths. If our radio telescope would allow a resolution of three million different directions, an all-sky, all-frequency search within the above parameters would be completed in approxi-

Although it is impossible for a Radio Amateur to perform such high resolution experiments, simple backyard interferometers can provide beamwidths as narrow as five degrees, depending upon the frequency of operation and the length of the baseline. (See **fig 6.**)

the search for intelligence

So far we have discussed only one aspect of radio astronomy, that of receiving and studying wide-band radio noise from non-intelligent sources located hundreds and even thousands of light-years away. The powerful nuclear reactions within these systems result in natural transmissions of formidable amounts of RF power to be detected by our rather primitive radio equipment.

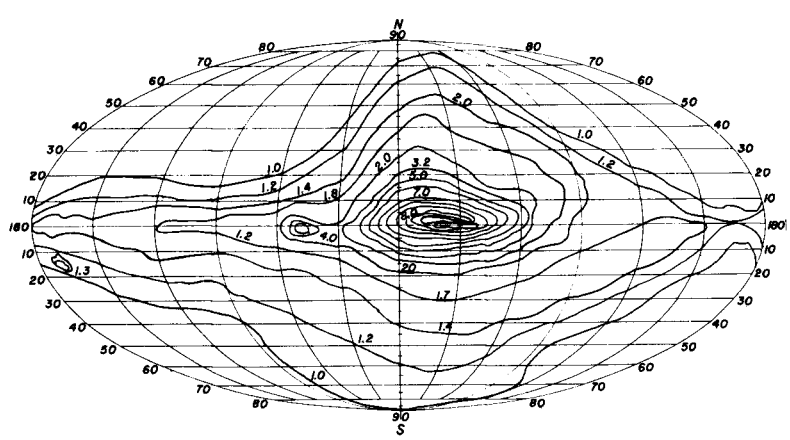

fig. 6. Higher (but still low) resolution mapping of the radio sky than in the case of simple radiometry can be obtained with narrower beamwidth antennas as in the case of amateur interferometry.

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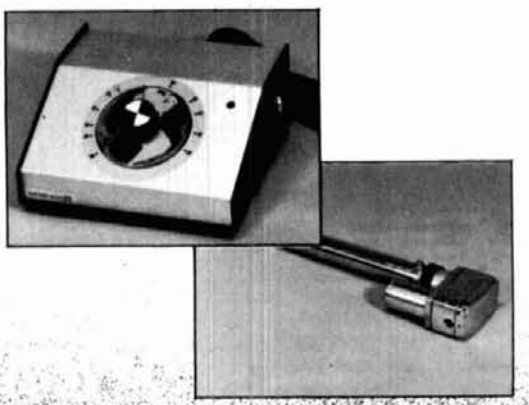

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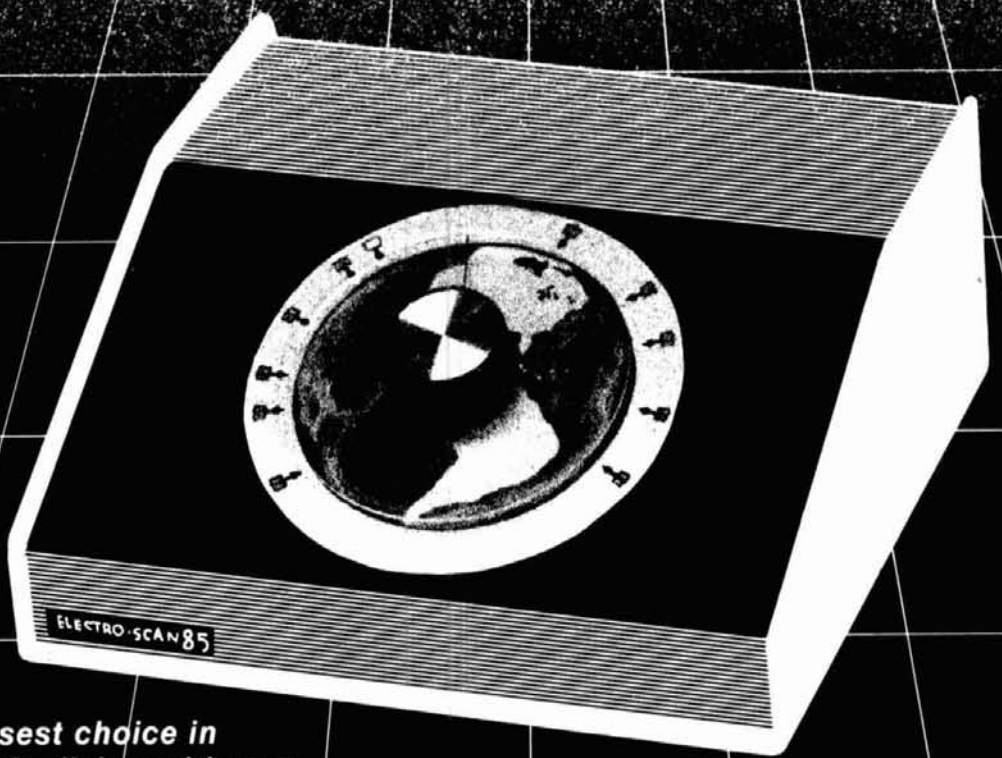

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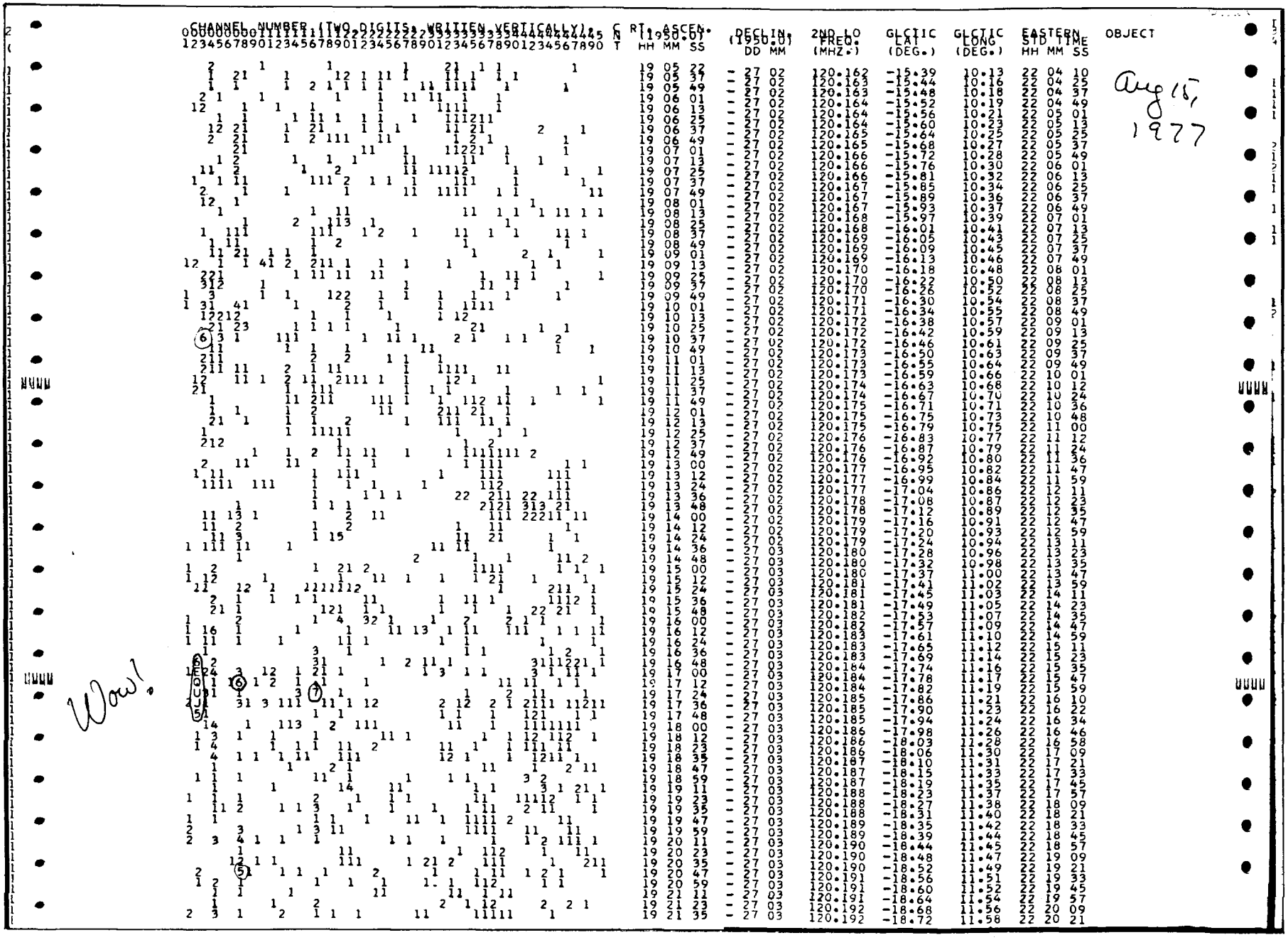

fig. 7. The famous "WOW" signal was received by the Ohio State Radio Observatory on August 15, 1977, at 22 hours 15 minutes and 35 seconds Eastern Standard Time. This signal is one of several mysterious signals received from outer space. Although it lasted only a minute, never to reappear, scientists are certain that the signal was of intelligent origin, and was issued from a source at least as distant as the moon. (*Courtesy of Ohio State University Radio Observatory.*)

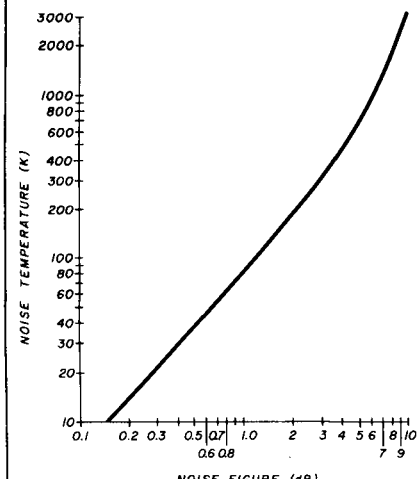

fig. 8. The logarithmic relationship between sky noise temperature expressed in degrees Kelvin and equivalent system noise figure expressed in decibels (dB).

mately ten million years — a rather impractical proposition for any mortal. We have to reduce the scope of our search, therefore, to match our time and technological limitations. Let's look at some of these limitations.

We can expect that in comparison with the natural RF sources previously discussed, intelligent signals transmitted from outer space would be of much lower power levels. Low power, in this case, could mean extraterrestrial transmitters of powers comparable to our strongest transmitters — one Gigawatt EIRP or more. Consequently, a terrestrial system intended for receiving these signals would have to operate against a quiet background so that its range would be limited only by its own noise figure, which should be no greater than the intergalactic noise level present at its antenna. See **fig. 8.**)

Although "intelligent" transmitters could be expected at almost any microwave frequency, radio astronomers have found a quiet range in the frequency spectrum that would be ideal for communication with civilizations attempting to communicate with us by radio. (This judgment is based upon our limited idea of what life is. It does not extend to other possibilities such as life forms based on elements other than carbon.)

Located between 1.4 GHz and 1.7 GHz, this area of the spectrum is the "water hole" frequency range. It exhibits a noise temperature of 6 to 8 degrees K (3 to 5 degrees K measured in space). This temperature would allow a 1-Gigawatt EIRP transmitter located approximately 26 light-years away to be heard with a modest backyard SETI radio telescope. (See **fig. 9.**)

The term "water hole" was suggested by the existence of two natural frequencies at each end of the band. Interest in persuing this concept was triggered in 1959 with the publication, in *Nature*, of a paper by Guiseppe Cocconi and Philip Morrison entitled "Searching for Interstellar Communications." Cocconi and Morrison pointed out the importance of radiation from hydrogen atoms reaching the Earth at an ideal spot on the frequency spectrum which coincides with the minimum background noise. At 1.42 GHz there is a natural radio beacon caused by interstellar hydrogen (H); another natural beacon exists at 1.66 GHz. This one is caused by hydroxyl (OH) ions traveling in space. When chemically combined on Earth, the two produce water (H_2O) — thus the terminology "water hole." Because hydrogen is the simplest, most abundant element in the universe, and because water is one

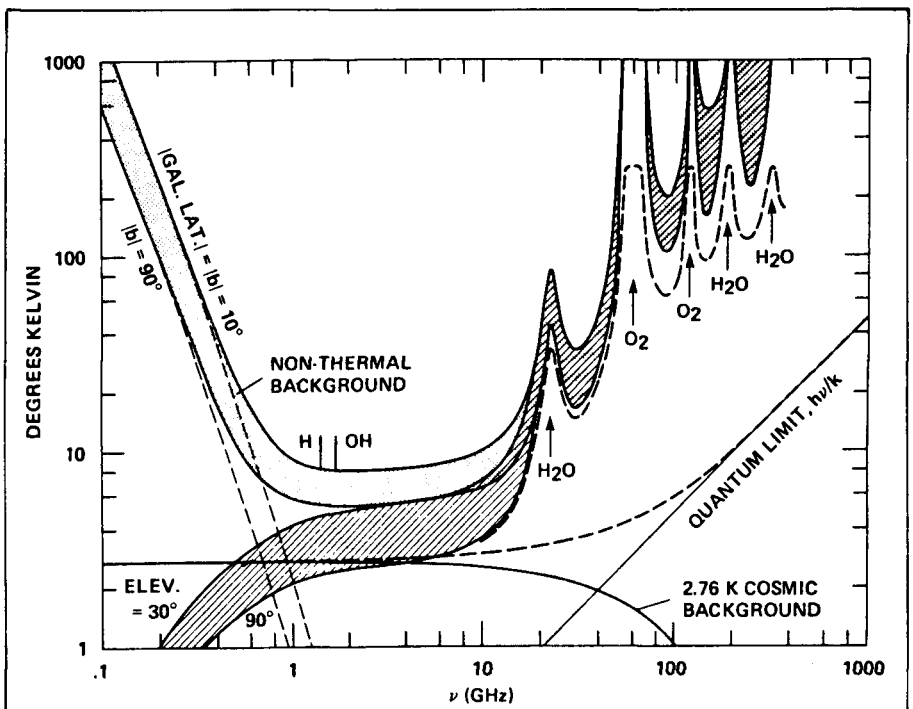

fig. 9. The "water hole" window provides the best overall noise performance for receiving intelligent transmissions from outer space. This frequency band has been suggested by astronomers as a possible radio meeting point for extraterrestrial civilizations which base their existence on water (see text).

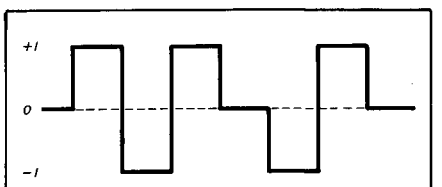

fig. 10. The concept of information obtained at the output of a circularly polarized, sense-switched receiver which is responding to a hypothetical binary circular polarization modulated signal and using a single frequency.

of the basic requirements of life as we know it, this frequency range has been favored by scientists as the "magic" band for interstellar communications. The concept of the water hole assumes two things: first, that all life in the universe is a function of water, and second, that any extraterrestrial civilization attempting to communicate with us would select this frequency band for the same reasons we did.

One important factor in receiving intelligent transmissions would be the signaling protocol and the rate of transmission used by the sending civilization and consequently the modulation scheme. If we may judge by our own experience, it is reasonable to assume that the sender would choose a simple two-state binary signaling scheme that could be modulated slowly (and therefore compatible with signal-to-noise bandwidth requirements) in one of four modulation schemes: amplitude, frequency, phase, and polarization.

A careful analysis of these modulation techniques indicates that the first three would be difficult to receive. If amplitude modulation were used, a binary "1" would be detected as the transmitter would be turned on. However, positive identification of the reverse state (i.e., 0) would be less probable because there would be no signal to reveal this information. While this method is acceptable in casual CW signaling, anti-cryptographic studies indicate that information would be lost if such a method were used (a true −1 state would be required for positive identification).

Two distinct binary states could be obtained with conventional frequency shift keying. However, the introduction of a new element — the second frequency — would make the search more difficult in view of the narrow bandwidths used. While phase modulation is a superior method for carrying data communication in that it requires only half the signal-to-noise ratio of the other modulation schemes for the same amount of information, it is thought to be the least likely to be used in searching for unknown signals.

The most likely method of radio communication that might be used by an extraterrestrial civilization is binary antenna polarization modulation using the same frequency. By properly changing between two orthogonal polarizations such as two perpendicular linear polarizations, or between left and right circular polarizations, the two binary states could be transmitted on the same frequency by switching the transmitter's output as shown in **fig. 10.** This in turn would allow for reversely polarized receiving antenna arrays on earth to receive the binary information and process it through two distinctive radio receivers as shown in **fig. 11** — or one receiver that would switch between two properly polarized antennas. Most searches for intelligent signals to date have been performed in the water hole frequency range using the latter method.

designing receivers

Over the past few years several methods have been suggested for receiving ETI signals. One technique — based on the "pulse" theory — stands a good chance of acceptance and is of interest to Amateurs because it requires simpler receiving equipment than other methods. This technique assumes the transmission of high power pulses of one second or longer in a digital binary format, as previously discussed. This concept makes sense because the average power available from a hypothetical extraterrestrial transmitter would probably be limited by thermal inefficiencies. (Although the topic is debatable, we assume that extraterrestrials would have technological problems similar to ours.) Much more peak power could be obtained from pulsed binary transmitters, which can overcome the noise figure limitations of target receivers and can be spread over relatively wider bandwidths so that complicated Doppler corrections would be minimized. Pulse receivers with ultimate bandwidths of up to 10 kHz have been used in the "magic" frequency range.

On the other hand, recent experiments favor the very narrow bandwidth/beamwidth beacon approach because of the superior signal-to-noise ratio obtainable. Using this concept, powerful beacons would be directed at the solar system chosen as an appropriate "target" by the sending civilization. The signal would be transmitted frequency-corrected so that it would be received on earth near the laboratory neutral hydrogen-line frequency (1.42 GHz/21 cm), thereby simplifying our search. The correction would include the source's Doppler shift and the frequency shift caused by the radial velocity of our sun, known by the sender from long-term astronomical observations of our solar system.

A terrestrial receiver would be equipped with multiple ultra-narrowband IF filters. The theoretical minimum bandwidth for interstellar communications has been recently calculated by Drake and Helou[2,3], who indicate that its limit is determined by the effects of the multipath scattering phenomenon resulting from turbulent ionized gases — the same effect that causes pulsar scintillation. Consequently, a pure carrier in the water hole will have a tendency to be wider at the arrival point than its originated bandwidth, say 0.01 Hz, after traveling 100 Parsecs (1 Parsec = 3.26 light-years). This can be important in the selection of bandwidth set as the limitation for practical filter design in SETI receivers.

Ultra-narrowband searches have been conducted at the Arecibo Observatory and at Harvard University by a ham radio operator, Professor Paul Horowitz, W1HFA. In 1978 Horowitz observed nearly 200 nearby stars similar to our sun at the 21-cm neutral hydrogen line wavelength by using the observatory's 305-meter dish (see **fig. 12**). The receiver (**figs. 13A, B,** and **C**) used a dual circular polarization feed which gave an effective antenna area of 22,000-m² (with 68-dB gain). The overall system temperature was 80 degrees K.

As shown in **fig. 13D** parametric amplifiers were used for the front end (new GaAs FET amplifiers have since

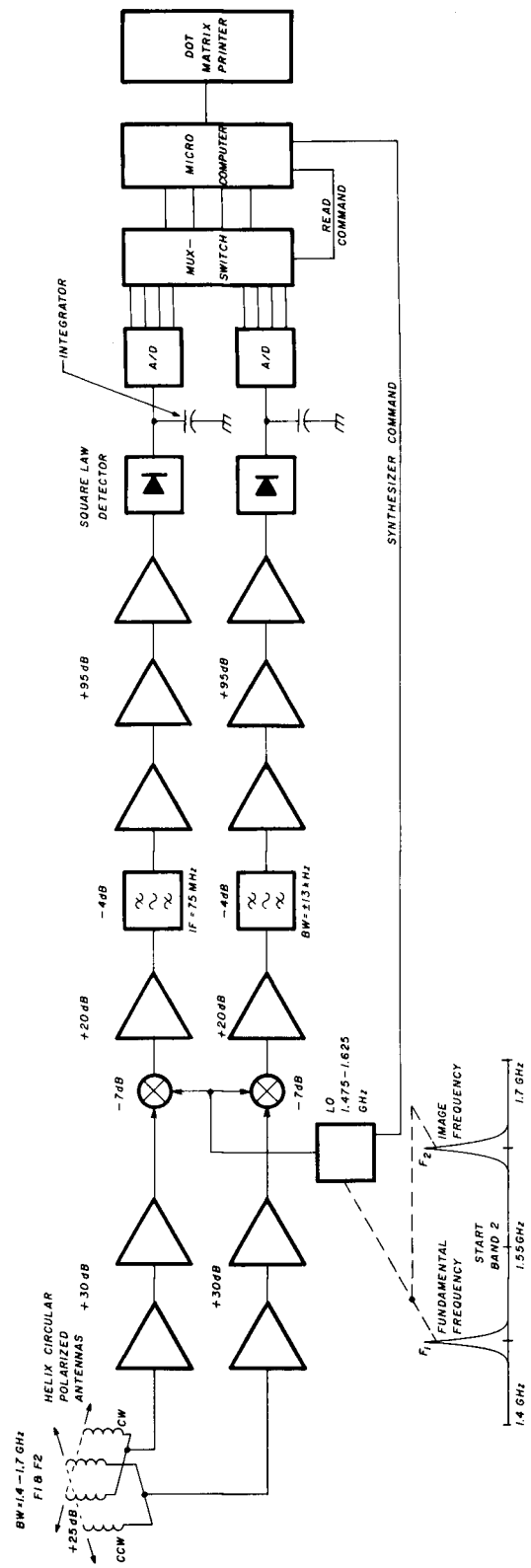

fig. 11. Block diagram of the author's SETI receiver, under construction. The system assumes circular polarization modulation (clockwise and counterclockwise). Dual diversity is achieved through the strategic choice of the 75-MHz IF, which allows image recovery in both modulation senses. Consequently, the entire 300-MHz water hole frequency band can be viewed in half the time it would otherwise take. Final selectivity is achieved with two crystal filters (4171-F monolithic from Piezo Technology) at 75 MHz. The bandwidth is ±13 kHz. The signal-to-noise problem introduced by the image recovery technique can be compensated for through longer integration time. The preamplifiers have a calculated noise figure of 0.4 dB (NEC NE 71083 and NEC 72084).

been installed) along with a dual conversion scheme having a first IF at 260 MHz and a second IF at 30 MHz. Crystal filters with bandwidths of 5 kHz were present in the second IF, followed by IF amplifiers. The final conversion to the sine and cosine basebands was achieved with a 30-MHz third oscillator. All local oscillators in the system were synthesized with a final resolution of 0.01 Hz and a short-term stability of $\Delta f/f = 5 \times 10^{-12}$ provided by a rubidium-referenced clock.

The quadrature baseband signals were then filtered by four-pole Butterworth low-pass tunable filters which were sampled under computer control with an analog multiplexer and 12-bit analog-to-digital converters. A single observation consisted of 64-K (65,536) complex samples at 1 millisecond intervals from each of two polarizations. The samples were digitized and recorded in real time onto nine-track digital magnetic tape for follow-up processing, which included a fast Fourier transform (FFT) on the quadrature signals.* A complete 64-K complex FFT and computation of power spectrum with the instantaneous resolution of 0.015-Hz per bin (compatible with minimum theoretical bandwidth discussed earlier) took about 15 seconds.

In the observations, it was assumed that a true celestial signal would have already been frequency-compensated for Doppler by the originating civilization. This included the sender's own velocity and the radial velocity of our solar system as observed by the sender, but not the residual Doppler resulting from the Earth's own rotation (not known to sender), which can shift such a signal through another 0.15 Hz of bandwidth at 1.5 GHz. This correction was implemented in the receiver's synthesized local oscillators (first LO and third LO) which were swept via real-time computer control — that is, the local oscillator was updated several thousand times during each observation. The synthesizer control mechanism set the first LO frequency at the beginning of each observation so that the third LO began at 30 MHz; the third LO was then updated at 20-millisecond intervals by computing frequency offsets in real time according to a polynomial algorithm which approximated the Earth's velocity according to data obtained from the Lincoln Laboratory planetary ephemeris.

One positive side effect resulting from this frequency sweeping through the ultranarrow bandwidths of the receiver was that earth-generated interference (which is generally not frequency swept) is completely rejected by the system. This was confirmed throughout the search by the absence of false alarms.

The Arecibo experiments revealed no evidence of ETI: Today the search

*FFT is usually used to break down complex waves.

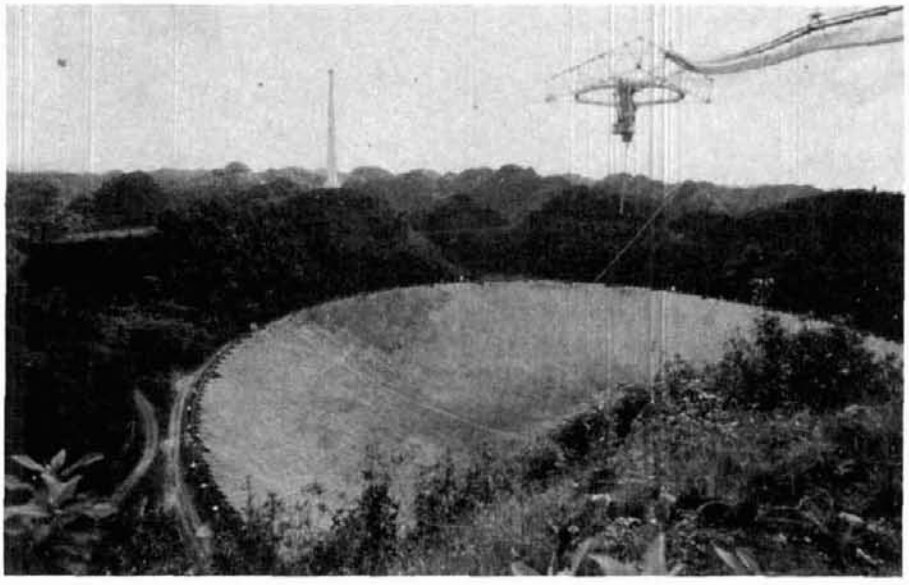

fig. 12A. Overview of the Arecibo Observatory, where in 1978, Paul Horowitz, W1HFA, observed nearly 200 nearby stars similar to our own sun at the 21-cm neutral hydrogen line wavelength. (*Photo courtesy of College of St. Thomas, St. Paul, Minnesota.*)

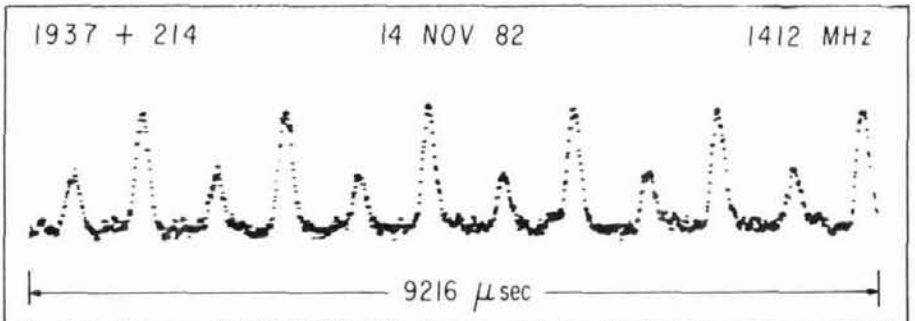

fig. 12B. Pulsar profile PSR 1937+214, discovered at Arecibo in 1982, measures only 3 miles across but releases 10 to 100 million times the energy of the Sun. Rotating around its gravitational axis at 642 revolutions per second, it pulses at 1.558-millisecond intervals; each pulse consists of two signal peaks or flashes of radio energy streaming out from its magnetic poles. Pulsars were first thought to be of intelligent origin because of their precise repetition rate. At Cambridge University in 1967, a signal was recorded at 1.33730-second intervals. Code-named *LGM* — "Little Green Men" — it was later proved to be the first known pulsating neutron star, or pulsar. (*Courtesy of Arecibo Observatory, part of the National Astronomy and Ionospheric Center operated by Cornell University under contract with the National Science Foundation.*)

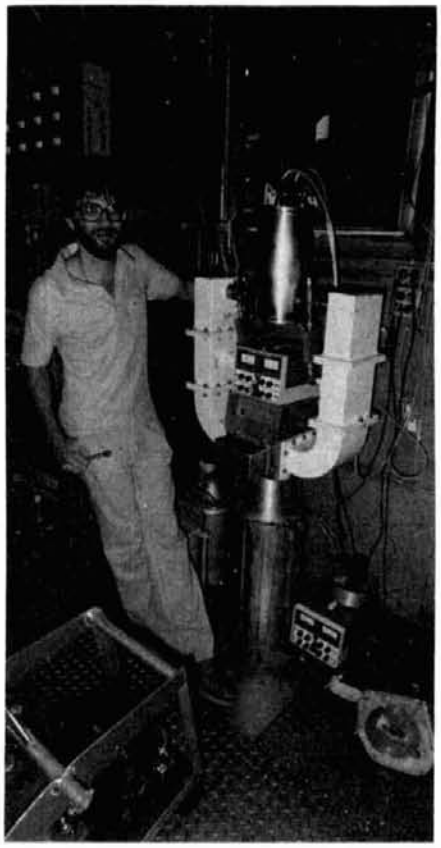

fig. 13A. Inside the carriage house of the Arecibo Observatory — suspended above the 1000-foot dish — engineer Bob Zimmerman, NP4B, proudly displays the new dual-channel 18-cm receiver front end (left and right circular polarizations). (*Photo courtesy of Arecibo Observatory.*)

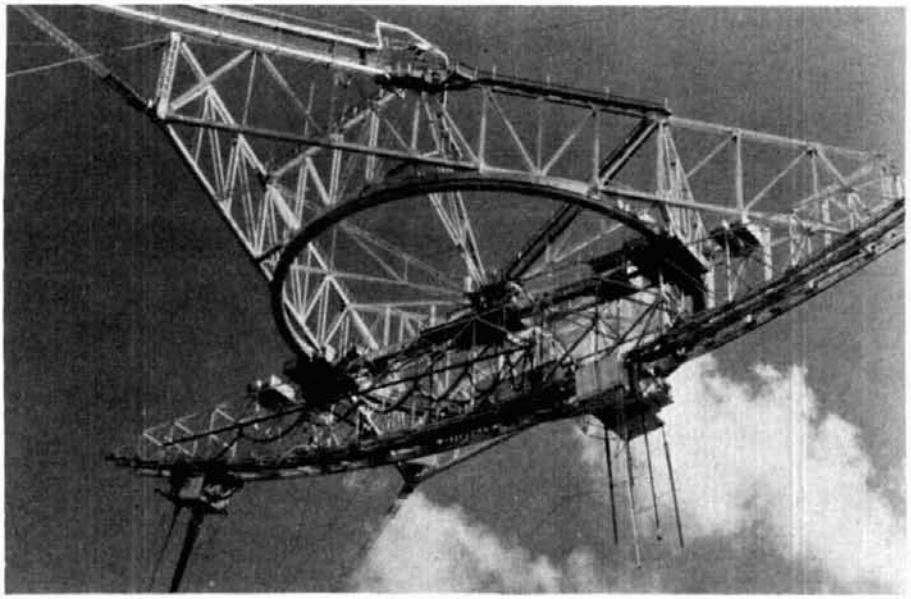

fig. 13B. The antenna feed passes through the floor of the carriage house and is focused in the dish, 430 feet (131.06 meters) below. The temperature inside the metal dome is held at 80 degrees Kelvin with liquid nitrogen in order to reduce the noise temperature of the front end. (*Photo courtesy of College of St. Thomas, St. Paul, Minnesota.*)

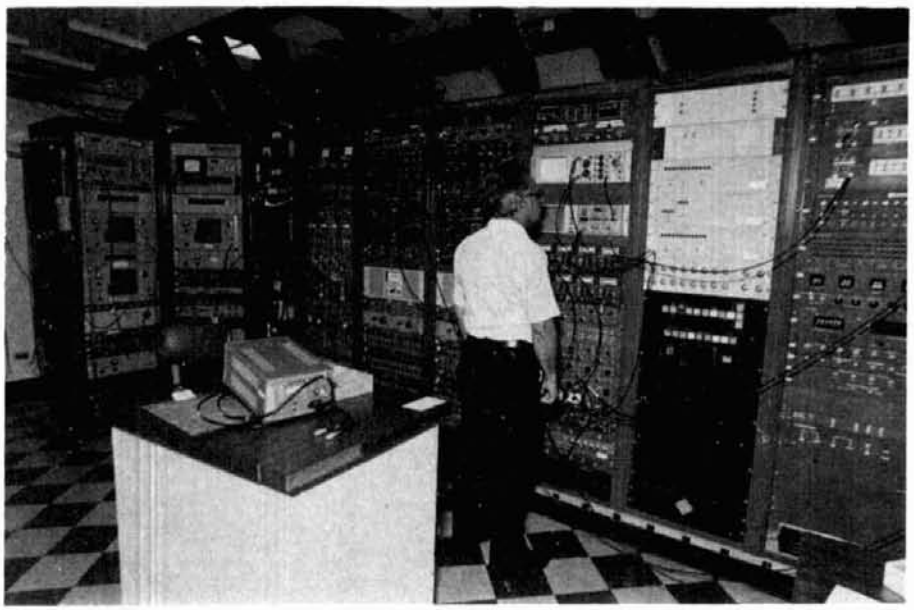

fig. 13C. The receiver room at Arecibo Observatory. The equipment contains oscillators, HP synthesizers, Rubidium standards, detectors, amplifiers, A/D converters — just about any electronic device needed by an astrophysicist. About 200 hours per year are dedicated to SETI. Searches have been made of approximately 1000 nearby stars at the Water Hole frequency. (*Photo courtesy of Arecibo Observatory.*)

continues with a special receiver in operation at the Planetary Society/SAI/Harvard project "Sentinel" as shown in **fig. 14**. This system matches the natural minimum bandwidth discussed earlier by also resolving the input bandwidth into 64K (65,536) complex frequency bins of 0.03 Hz each. The 84-foot radiotelescope is equipped with two dual-circularly polarized feedhorns (5 bands) connected to two receivers. The front end consists of two identical 35-dB gain, 55 degrees K (uncooled), 10 degrees K (cooled) GaAs FET preamplifiers operating in the waterhole frequency band. (Other frequencies can be tuned.)

The receiver uses a conventional single conversion scheme with an IF of 30 MHz. Image rejection mixers, broadband IF amplifiers and filters are used in conjunction with a computer-controlled synthesizer. The 30 MHz IF signals are then sent to the back end of the receiver, located in the control building via low-loss rigid coaxial cables. As in the case of Arecibo, the back end is responsible for sweeping through the 30 MHz IF to compensate for the Doppler shift caused by the Earth's rotation. The result is a quadrature baseband combination of

signals which is further filtered through 6-pole low-pass anti-aliasing filters. The control computer updates the LO 40 times per second based on an ephemeris table calculated at the beginning of each run. Sample-and-hold amplifiers and 8-bit analog-to-digital (A/D) converters are used to feed the FFT processors via interrupt-driven parallel ports.

Although the Harvard installation surpasses, by at least an order of magnitude, the combined efforts of all previous SETI (in terms of system sensitivity, the number of sky positions observed, and the number of concurrent channels), scientists feel that the search should be expanded in frequency by a factor of at least 100.

This would mean increasing the present 64-K channels used in each of two polarizations to about 8.4 million channels of 0.05-Hz resolution, thus increasing the probability of intercept (POI) by a factor of 100. Consequently, the instantaneous bandwidth would increase from the present 2 kHz to 420 kHz. Although this would be quite an improvement, it would still be insufficient to cover the 300-MHz bandwidth of the water hole at once. An all-sky water hole search with the new receiver would still require 1200 instantaneous bandwidths of 420 kHz times the number of sky locations.

Because no receiving system can cover the entire sky at all frequencies at once, much more work remains to be done in SETI, and while omnidirectional wideband pulses have been suggested as a SETI method, the narrowband beacon concept gives superior S/N ratios not achievable otherwise. On the other hand, Doppler corrections associated with the beacon approach, which would require hard-to-design high-resolution microwave synthesizers, make the pulse concept attractive at least for the Radio Amateur. New methods of observing many RF sources simultaneously using Bragg-Cell technology have been suggested. However, the relatively wide channel bandwidth produced by today's Bragg technology, combined with the low receiver dynamic range, limits the applicability of this technology.

We have looked at several radio astronomy systems, from a simple radiometer to the ultra-narrowband receivers used by professional radio astronomers. Although this article is not intended as a construction paper (ample details are provided in the references), some elements of design should be considered before a system approach is chosen. The block diagram shown in **fig. 15** shows an economical approach to designing an Amateur Radio astronomy center operating in the water hole frequency band. It could be used as a wideband radiometer, an interferometer, or as a tunable narrowband receiver intended for the reception of pulses if care is taken in providing short-term stability for the local oscillators along with narrowband filtering in a third conversion.

This system would consist of a two-stage GaAs FET preamplifier with a low noise figure. Several designs have been recently published in the literature. The expected gain from such amplifiers is typically in the 30 dB range or better. This would be sufficient to overcome the high noise figure of the following mixer (7 dB). Recent designs using the Mitsubishi MGF 1412-11-09 and MGF-1412-11-10 GaAs FET transistors claim noise figures of about 0.5 dB (35 degrees K). Older designs pro-

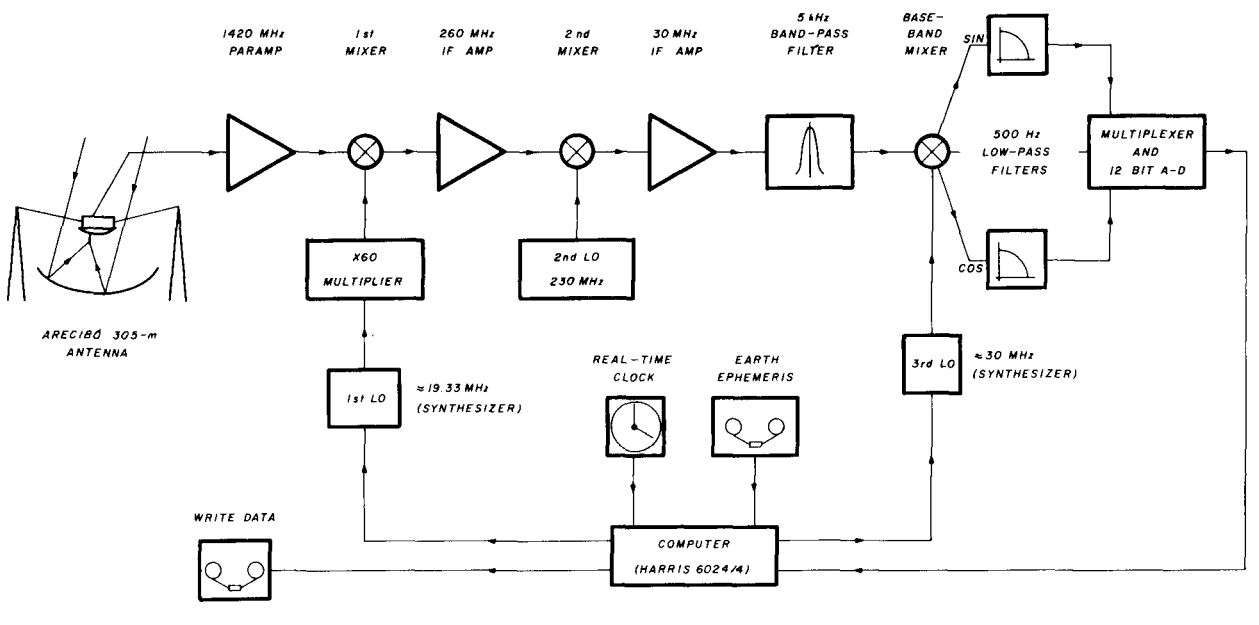

fig. 13D. Block diagram of the Arecibo system as used for SETI in 1978 by Professor Paul Horowitz (W1HFA). Frequency sweeping of the local oscillators was used to compensate for Doppler shifts caused by the earth's rotation. (See text).

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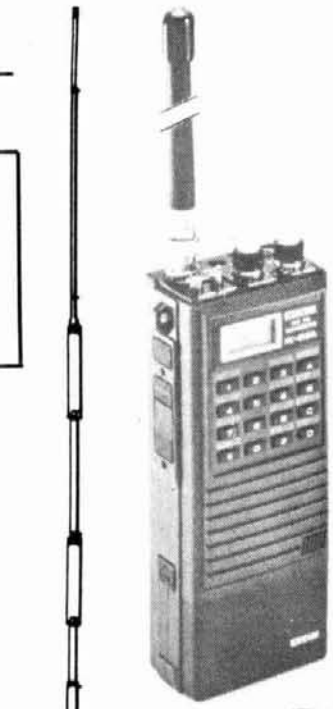

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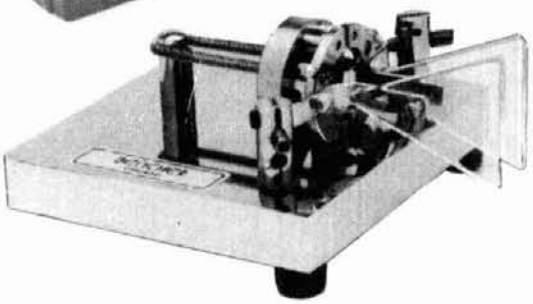

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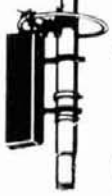

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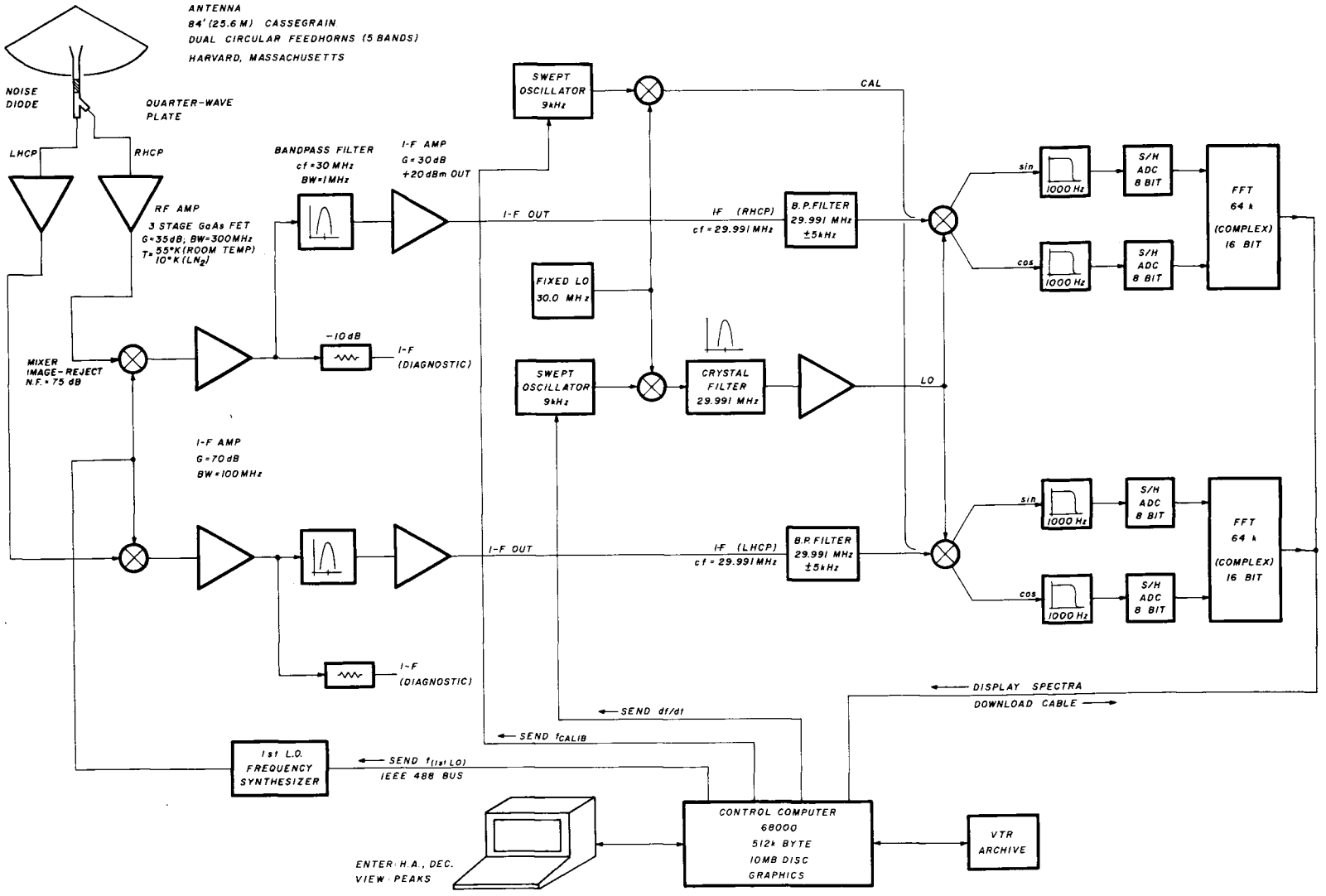

fig. 14. Block diagram of the Ultra-Narrowband SETI receiver used at Harvard University. The system uses an 84-foot (25.6 meter) equatorial radiotelescope with a single conversion dual polarization receiver intended for processing left and right circular polarizations at the same time. (*Courtesy of Harvard University Physics Department.*)

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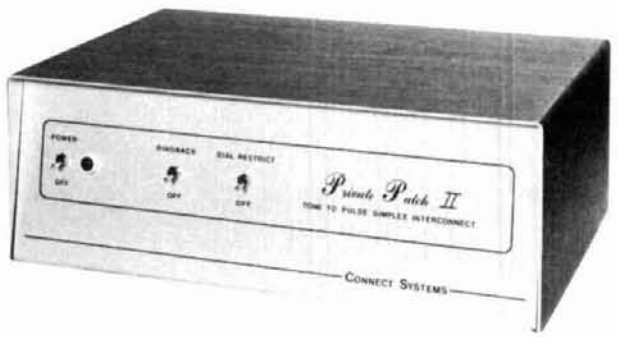

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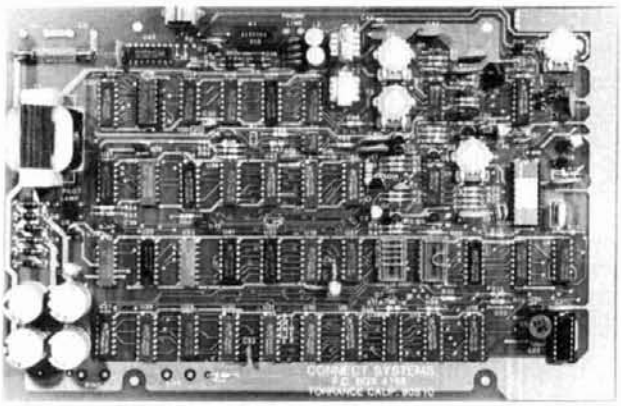

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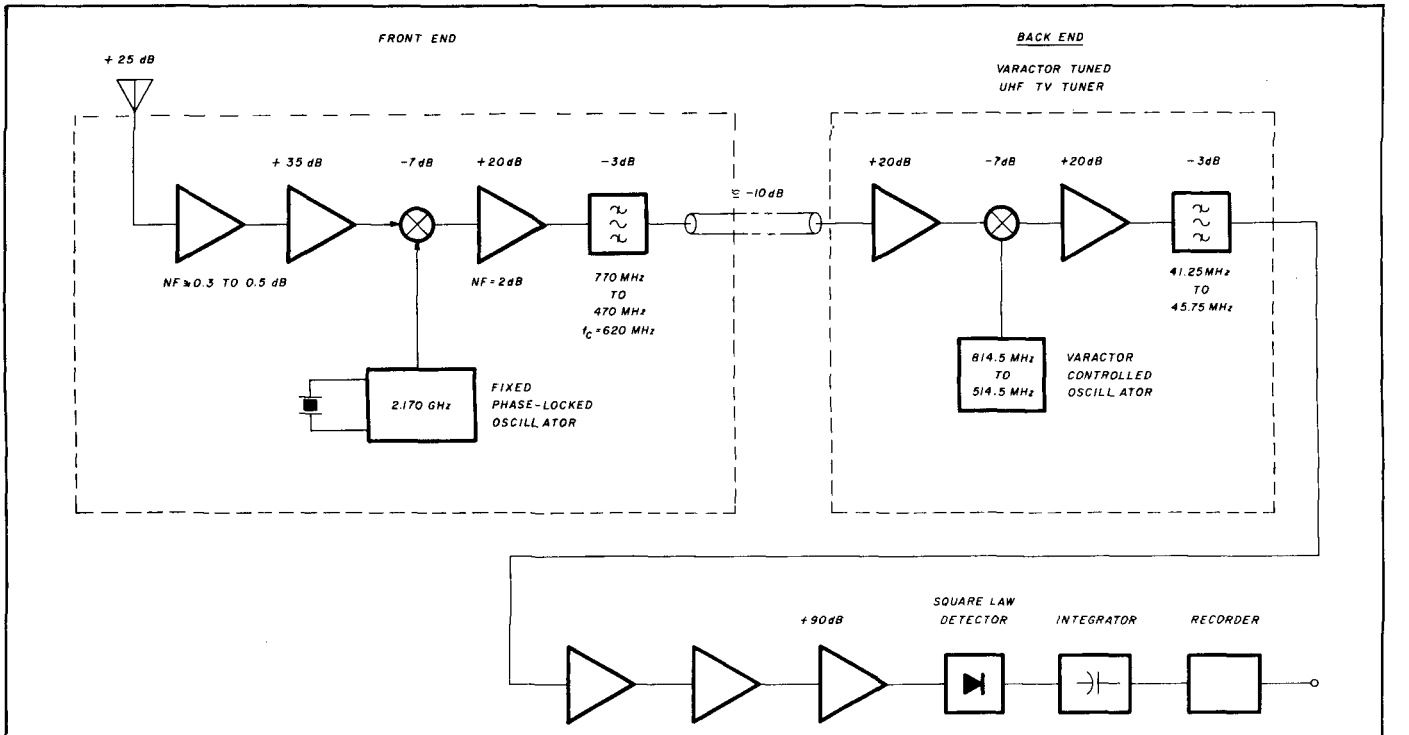


fig. 15. Block diagram of an economical amateur radio astronomy receiver.

vide noise figures in the 0.8 dB (58 degrees K) range with about the same gain. Stripline approaches on G-10 material or open frame designs have been extensively covered in the reference material at the end of this article along with simple rat-race mixers intended for 1.296 GHz or 2.3 GHz. (Mixers can also be purchased from a variety of manufacturers.)

Our receiver would use the first mixer in conjunction with a fixed phased-locked loop or multiple chain synthesizer at 2.170 GHz. (Such designs are popular in satellite converters and other devices.) The first IF would be purposely chosen to fall in the UHF range where an inexpensive varactor-type TV-tuner could be used as a second tunable IF over the entire water hole frequency of 300 MHz. The part investigated was a Mitsumi UES-A 56F, which is marketed by several companies, including Radio Shack. This tunable converter exhibited a total noise figure of about 6 dB and 15 dB of gain, with an acceptable short-term stability at room temperature compatible with an ultimate bandwidth of 10 kHz (care should be exercised to provide isolation of this unit from the front end because harmonics of local oscillator fall in the input range of the receiver). The tests were performed with a precision power supply having a range of 0 to 28 volts. If only a radiometer is contemplated, the phase-locked first LO is not mandatory and the control voltage applied to the second converter should be chosen about halfway on the voltage curve and should be double regulated.

The UHF converter provides a TV-compatible IF, centered at 44.5 MHz, with a bandwidth of 6.5 MHz. This output could be used directly with a modified high-gain TV-IF with the

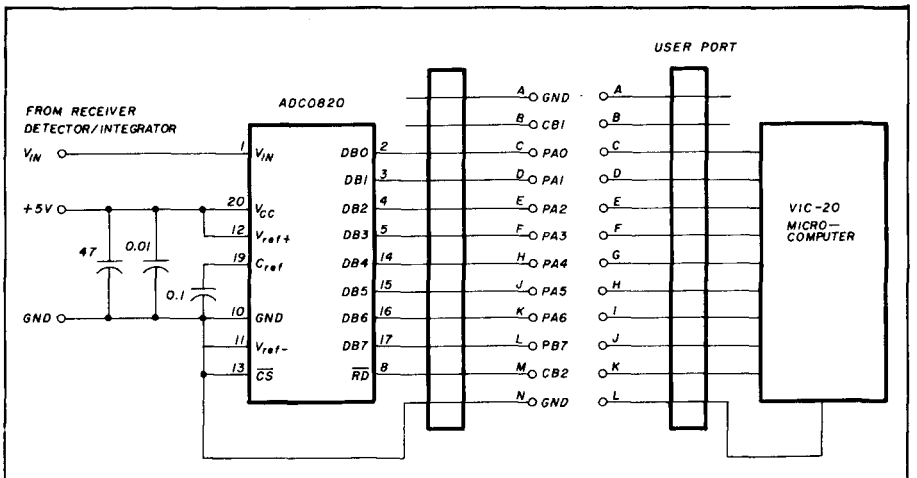


fig. 16. Schematic diagram of a simple A/D interface for a radio telescope. No additional parts are needed to perform consecutive readings; the information can be printed out as relative flux data by a dot-matrix printer directly from the microcomputer.

the candidate stars:
which stars might support life?

Although our knowledge is limited, it appears that the universe is expanding — that is, the galaxies are moving apart from each other. This movement suggests a "time of beginning" in a cycle (known as the "big bang" event) that began with an explosive fireball of matter inside a huge black hole with no conceivable limits some fifteen billion years ago.

Certain stars of various sizes evolved from the cold gas of a previous cycle; these are now in their "main sequence," but approaching a "finale" as shown in **fig. A**. Depending on their mass and temperatures, they are classified by letters, with the hottest designated by the letter O, and followed in descending order by other spectral types such as B, A, F, G, K, and M. In the search for extraterrestrial intelligence only type F, G, and K stars are of interest to us because they are the right size and temperature for supporting life on planets similar to our own. (Our sun is a type G2 yellow star.) With some three hundred billion stars in the Milky Way galaxy alone — and ten billion other galaxies in the known universe — we can identify approximately one million nearby candidate stars (within 1000 light-years) of spectral type F, G, or K that could conceivably support life. Despite the magnitude of this number, only a handful of stars (see **table 1**) are within the Amateur's technological reach. Of this handful, the nearest are in Alpha Centauri. Located some 4.3 light-years away, Alpha Centauri is a triple system containing two massive suns (Type G4 and Type K1) separated by some 20 astronomical units (1 A.U. equals the mean distance of the Earth from the sun) and revolving around each other along with a smaller third star, Alpha Centauri C (a type M star). Recent investigations indicate that this system may be much younger than ours, suggesting that advanced forms of life would probably not have developed even if a planetary system did exist within its complex rotational set-up. Other theories, however, might explain a heightened probability of life on Alpha Centauri as shown in **fig. B**.

Of approximately 40 stars located not more than 16.7 light-years from Earth, only two — Epsilon Eridani (type K2) and Tau Ceti (type G4) — have been identified as meeting the conditions necessary for the existence of advanced forms of life. Similar to our sun but somewhat smaller, Epsilon Eridani is located 10.5 light-years away in the constellation Eridanus. Tau Ceti is located approximately 10.8 light-years away in the constellation of the Whale. Rather dim compared to our sun, it is visible from Earth's northern hemisphere only during the winter months. These two stars were among the first to be observed by Frank Drake and his team at the National Radio Astronomy Observatory (NRAO) in Green Bank, West Virginia, in 1960 under the project name *Ozma*, a name borrowed from the Wizard of Oz. No evidence of extraterrestrial intelligence has been observed to date.

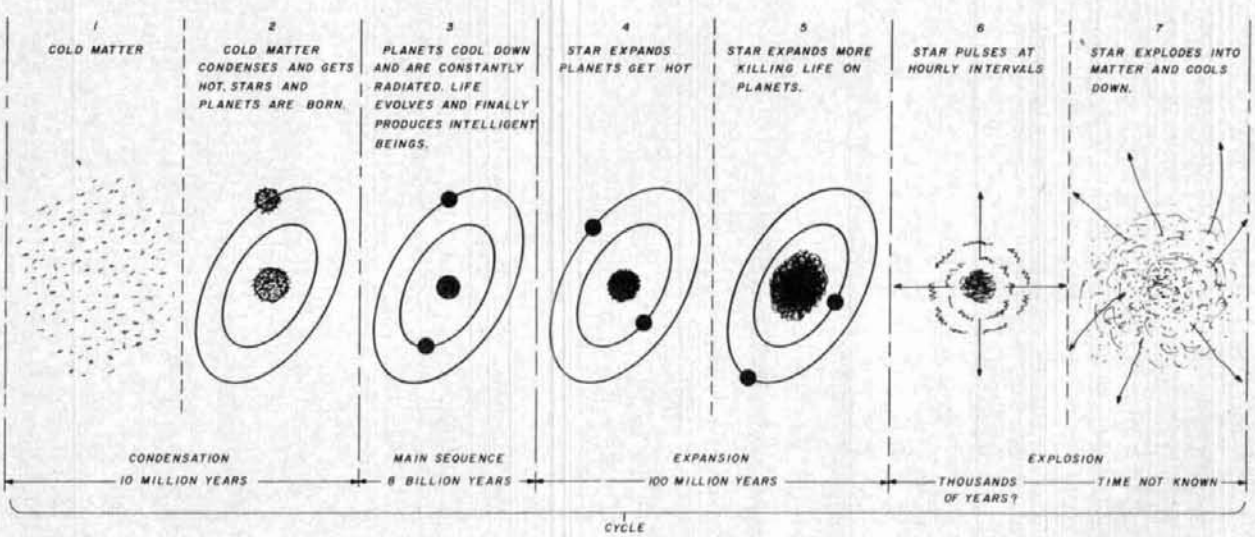


fig. A. One concept of star evolution suggests that the possibility of life on planets revolving around a type G yellow star occurs during its "main sequence". This type of star is similar to our own sun. A "lucky" planet similar to Earth would need approximately four billion years of continuous energy flow from this star to allow the random process of mutation on elements to produce the complexity of the human brain, which has made possible the development of communication technologies.

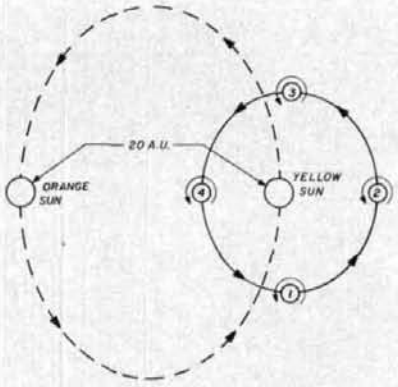


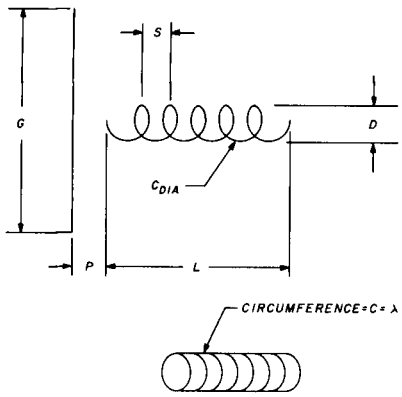
fig. B. The concept of two suns — one yellow (Alpha Centauri A, type G) and the other orange (Alpha Centauri B, type K) — rotating around each other in the triple star system Alpha Centauri, located some 4.3 light-years away. If an earth-like planet were to exist at the same distance from the yellow star as the earth is from the sun, it is conceivable that the complex rotational relationship would allow for long alternating yellow and orange days — with no nights — which may accelerate the development of life on this relatively young system.

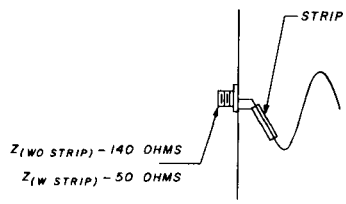
One of the more recent additions to the list of "interesting" stars is Vega, located 26 light-years away from Earth in the constellation Lyre (Lyra). Vega is the third brightest star in the sky. Although twice the size of the sun, its surface temperature has been measured and found to be almost the same. A relatively young star — at only one billion years old — Vega is important to us because of the discovery, in 1983, of a possible planetary system around it by the infrared astronomical satellite (IRAS). According to astronomers, while the infrared telescope aboard IRAS was sensitive enough to detect a mass rotating around Vega equivalent to the combined mass of all nine planets in our solar system, it could not resolve the objects precisely enough to distinguish among them. Nonetheless, this is one of the most compelling pieces of data suggesting that we may have another planetary system in the universe. (This theory is now being challenged by another interpretation; some investigators view the phenomenon as a belt of dust consisting of "pellets" that reradiate the star's infrared energy.)

table 1. Stars within 26 light-years which could have habitable planets (adapted from Stephen H. Dole, 1964.)

name of star	spectral class	approximate distance (light years)
Alpha Centauri A	G4	4.3
Alpha Centauri B	K1	4.3
Alpha Centauri C	M1	4.3
Lal 21185 (A)	M1	8.2
ϵ Eridani	K2	10.8
61 Cygni A	K5	11.1
61 Cygni B	K8	11.1
ϵ Indi	K5	11.3
Grm 34 A	M2	11.7
Lac 9352	M1	12.0
τ Ceti	G8	12.2
Lac 8760	M0	12.6
Cin 3161	M3	14.9
Grm 1618	K8	14.9
CC 1290	M3	15.4
Cin 18,2354	M3	16.1
+15° 2620	M1	16.9
70 Ophiuchi A	K1	17.3
70 Ophiuchi B	K5	17.3
η Cassiopeiae A	F9	18.0
η Cassiopeiae B	K6	18.0
σ Draconis	G9	18.2
36 Ophiuchi A	K2	18.2
36 Ophiuchi B	K1	18.2
36 Ophiuchi C	K6	18.2
HR 7703 A	K2	18.6
HR 5568 A	K4	18.8
HR 5568 B	M0	18.8
δ Pavonis	G7	19.2
−21° 1377	M0	19.2
+44° 2051 A	M0	19.2
+4° 4048 (A)	M3	19.4
HD 36395	M1	20.0
+1° 4774	M2	20.2
+53° 1320	K7	20.2
+53° 1321	K9	20.2
−45° 13677	M0	20.6
82 Eridani	G5	20.9
β Hydri	G1	21.3
HR 8832	K3	21.4
+15° 4733	M2	21.8
ρ Eridani A	K2	22.0
ρ Eridani B	K2	22.0
HR 753 A	K3	22.0
Vega	G4	26.0

sound trap removed or with a home-brewed IF of a lower noise figure. Full rectification could be implemented for detection in conjunction with simple integrators and DC amplifiers. Fast Fourier transforms (FFT) could also be implemented by using inexpensive microcomputers. The receiver's output transducer could be one of the newer A/D converters — such as National's ADC0820 — connected to a microcomputer and a dot matrix printer. This converter eliminates the extra circuitry normally associated with interfacing A/Ds to microcomputers as shown in **fig. 16**. It was specifically designed to appear as memory locations or I/O ports to a standard microprocessor, with no other logic needed. In addition, the converter's input acquisition time is much faster than its conversion time, lending its use to measuring many analog signals upon software commands without the aid of additional sample-and-hold devices. The resolution is 8 bits, with a





$C_{DIA} = 0.017\ \lambda$ — conductor diameter

$D = \frac{\lambda}{3}$ OD — loop diameter

$G \geq 0.8\ \lambda$ — ground plane

$N \geq 3$ — N = 9 for 14.8 dB; N = 12 for 16 dB

$S = \frac{\lambda}{4}$ — space between turns

$\lambda_{(IN)} = \frac{11{,}810}{f(MHz)}$ — wavelength free space

$P = 0.12\ \lambda$ — space from reflector to first turn*

*observe impedance matching stub

(A) Theoretical formula for designing a helical antenna.

F_{RANGE} = 1400 MHz to 1700 MHz
BW = 300 MHz
C_f = 1550 MHz
if C = λ

$$BW\ is \left| \frac{1550\ MHz}{-20\%\quad C_f \quad +30\%} \right|$$

ANTENNA BANDWIDTH 3 dB POINTS (C_f = 1550 MHz) IS:
BW 1240 MHz to 1860 MHz

$\lambda = \frac{11{,}810}{1550} = 7.6193$ INCH

$C_{DIA} = 0.017\lambda = 7.619 \times 0.017 = 0.1295$ inch

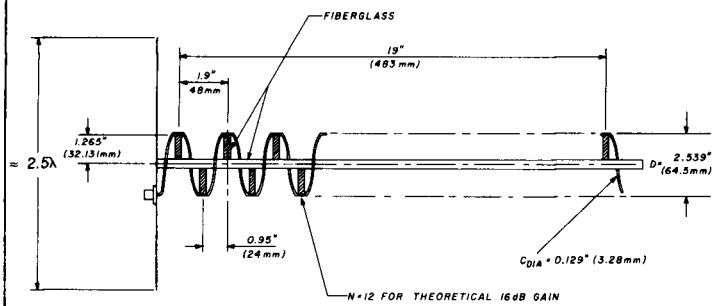
$D = \frac{\lambda}{3} = \frac{7.6193}{3} = 2.539$ inch

$G \geq 0.8\lambda \geq 0.8 \times 7.6193 \geq 6.09544$ inch

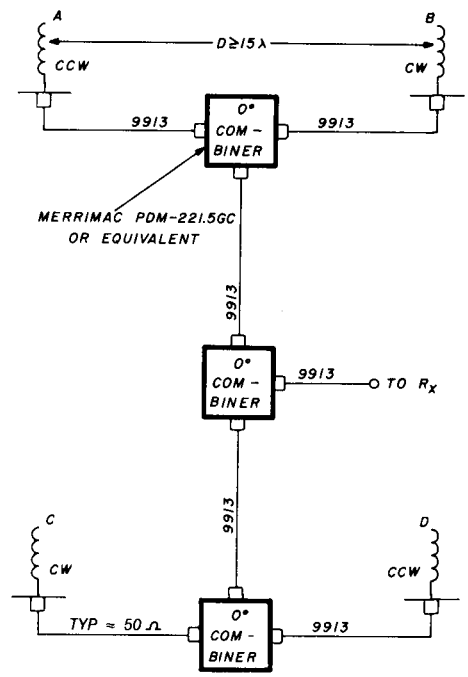
$P = 0.12\lambda = 0.12 \times 7.6193 = 0.9143$ inch

$S = \frac{\lambda}{4} = \frac{7.6193}{4} = 1.90$ inch

(B) Actual design of a helical antenna for the water hole frequency band.



(C) Construction details.



summary of polarization combinations

A + B → Horizontal
A + C → Vertical
A + D → Clockwise
B + C → Counterclockwise
A + B + C + D → Linear

(D) An array of four helical antennas can be arranged to provide narrow beam width and many different polarization patterns. Additional LNA's can be introduced in each of the antenna legs to overcome the noise figure of the combiners.

fig. 17. Design of a helical antenna system for the water hole frequency range.

maximum conversion time of 1.2 microseconds, an ideal application for a radio astronomy center. The ADC0820 chip was tested with the VIC-20 microcomputer, but would be equally applicable to any microcomputer having a latched data bus. With the proper software, the output of the computer can be printed out at equal time intervals in relative flux units on a scale of 0 to 5 volts (or 0 to 9 volts with a modified reference).

what antenna to use

The best antenna for radio astronomy is still the parabolic dish, as proven by most professional radio astronomy centers. Some Amateurs are reportedly using computer-controlled steerable dishes as large as 60 feet in diameter. But unless Amateurs have access to large backyards and friendly neighbors, they cannot proceed to construct such large arrays. Reasonable gains, however, can be obtained with arrays of axial mode helix antennas. The helix is attractive at 1.5 GHz mainly because of its relatively small size. The design shown in **figs. 17A, B,** and **C** indicates that the length of a helical beam at this frequency would be about 19 inches with a 2.5-inch diameter and a minimum reflector size of only 0.8 wavelength. This would make an inconspicuous installation. Although the helical antenna is not known for its gain, it has been used extensively by professional radio astronomers. A nine-turn helix antenna can provide about 14.8 dB, and a twelve-turn helix, about 16 dB of gain.

Helix antennas have also been used in more moderate arrays with gains in excess of 25 dB. Depending on which way they are wound in regard to each other, several polarization schemes can be accomplished. For example, using a pair of helices with the same sense (both clockwise or vice-versa) can provide circular polarization. Using opposed windings allows for horizontal polarization. A four-antenna array with clockwise and counterclockwise components can be interconnected so that several choices of polarizations could be obtained, as shown in **fig. 17D**. In addition, beamwidths of 10 to 15 degrees have been achieved.

The main characteristic of the helix antenna is its relatively wide bandwidth (-20 percent and $+30$ percent of the center frequency), which makes it suitable for the water hole band. Unless terminated with a matching strip or at a special point on the back plane, a helix exhibits a high impedance output of about 140 ohms. Inasmuch as this could be a disadvantage in a single-antenna design, parallel arrays using high-impedance coaxial cables can produce composite outputs of 75 ohms without the use of RF combiners.

On the other hand, a helix antenna can exhibit a much higher noise figure than the parabolic dish. Because the noise temperature of an antenna is determined by the noise power available in its lobes (this includes its minor lobes), if the antenna is "looking" at the ground — which has a typical noise temperature of 290 degrees K (17 degrees C) — it will have a noise figure of approximately 3 dB, which would be much higher than that of a preamplifier. In this respect the parabolic antenna would be better (lower side lobes). Careful consideration for the location of helical array is recommended; the choice of polarization, explained earlier, can also greatly improve the system. Fourier transforms performed with simple microcomputers will also help in separating the desired components from the noise in these lobes.

conclusion

Although it may be difficult for Radio Amateurs to accept the seemingly impractical nature of radio astronomy projects, the experience gained in developing one's own system could provide a complete education in contemporary radio communication.

Detailed information on the construction of radio astronomy and SETI projects, including low-noise amplifiers, and fast Fourier transform (FFT) programs for simple microcomputers can be obtained from The Society of Amateur Radio Astronomers (SARA) which publishes several books on the subject along with a monthly newsletter. At present, The Society has 168 members worldwide, many of whom are hams as well as scientists and engineers working in related fields. For more information, write to Robert M. Sickels, Secretary, SARA, 7605 Deland Avenue, Fort Pierce, Florida 33451.

There are many arguments about the existence of extraterrestrial intelligence. Some scientists believe that intelligent life exists elsewhere in the universe, while others mathematically analyze the probabilities and conclude that we could very well be the only advanced civilization in our galaxy. While this is a discouraging thought, we cannot rule out the possibility that there may be a few others out there — perhaps many others. Although we have no evidence yet to support the claim that ETI may exist, many scientists have been taking the task of SETI very seriously, and an increased number of receiving stations built by Radio Amateurs would only improve the chance of receiving that first intelligent signal from beyond our own solar system. We know that the laws of physics are the same throughout the universe; an advanced civilization, therefore, regardless of what it used to produce RF energy, would radiate the same kind of RF energy we know here on Earth. Our modern RF technology is now producing receivers with noise figures that approach the limitations of intergalactic noise. The gap has finally been closed; *we can now begin the final search.*

acknowledgements

I wish to thank Garred Giles (ex KP4EPM) of the Arecibo Observatory for providing key photographs taken especially for this article. My appreciation is also extended to Dr. Harry Webb of the College of St. Thomas in St. Paul, Minnesota, for sharing his collection of photographs taken in his many trips to the Arecibo Observatory. I would also like to thank Dr. Robert S. Dixon, W8ERD, Assistant Director of the Ohio State Radio Observatory;

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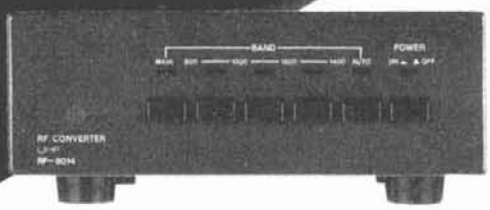
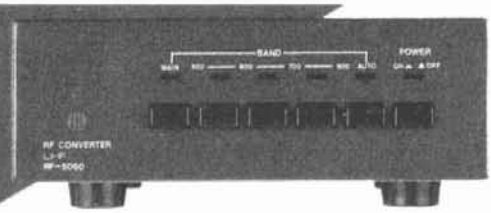


RF-8014 DOWN CONVERTER

800MHz – 1.4GHz RF converter for SX-400

● Bands: • MAIN (to cover 26–520MHz with SX-400) • 800MHz – 1.0GHz • 1.0GHz – 1.2GHz • 1.2GHz – 1.4GHz • AUTO (Automatic control of RF-8014 with an external computer, etc.) ● Frequencies shown in SX-400 display: 500MHz lower between 800MHz – 1.0GHz, 700MHz lower between 1 – 1.2GHz, 900MHz lower between 1.2 – 1.4GHz ● Individual Band Switches and LED Indicaters ● Current Drain: 250mA (approx.) ● Accessories: 1 BNC/M-adapter, 1 Cable with BNC terminals ● Dimensions: W 148 × H 51 × D 225(mm)



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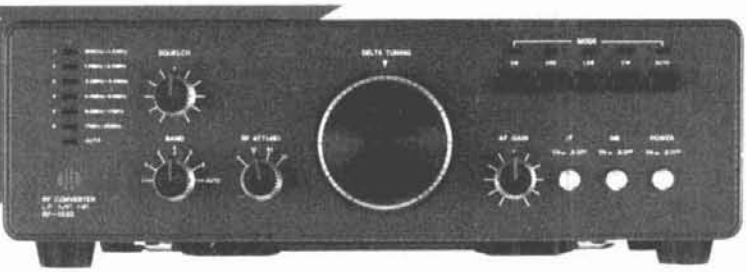
500 – 800MHz RF converter for SX-400

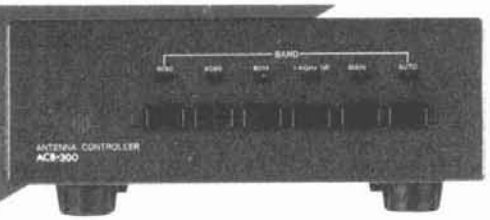
● Bands: • MAIN (to cover 26-520MHz with SX-400) • 500 – 600MHz • 600 – 700MHz • 700 – 800MHz • AUTO (Automatic control of RF-5080 with an external computer, etc.) ● Frequencies shown in SX-400 display: 300MHz lower between 500 – 600MHz, 400MHz lower between 600 – 700MHz, 500MHz lower between 700 – 800MHz ● Individual Band Switches and LED Indicaters ● Current Drain: 250mA (approx.) ● Accessories: 1 BNC/M-adapter, 1 Cable with BNC terminals ● Dimensions: W 148 × H 51 × D 225(mm)



RF-1030 UP CONVERTER

100KHz – 30MHz RF converter for SX-400

● Bands: (1) 100KHz – 1MHz, (2) 1 – 2MHz, (3) 2 – 4MHz, (4) 4 – 8MHz, (5) 8 – 17MHz, (6) 17 – 30MHz • AUTO (Automatic conrol of 6 bands of RF-1030 with an external computer, etc.) ● Frequencies shown in SX-400 display: 50MHz higher on all bands than the frequencies received ● Individual Mode Switches and LED Indicaters: AM, USB, LSB, CW, AUTO • CW filter (optional) required for CW reception • AUTO — Automatic Control of modes of RF-1030 with an external computer, etc. ● Band Switch and LED Band Indicaters: Squelch Control, RF Att., AF Gain Control, Delta Tuning, IF ON/OFF Switch, NB (Noise Blanker) Switch ● Current Drain: 1A (approx.) * Power Supply Unit P-1A (optional) required for RF-1030 ● Accessories: 1 BNC M-adapter, 2 Cable with BNC terminals ● Dimensions: W 300 × H 90 × D 233(mm)



ACB-300 ANTENNA CONTROL BOX

Manual and Automatic antenna control system for SX-400 series RF converters

● Individual Band Switches and LED Indicaters: 1030, 5080, 8014, 1.4GHz UP (for reception of 1.4GHz above) AUTO (Automatic control of antennas for RF-1030, RF-5080, RF-8014 and for MAIN scanner) ● Current Drain: 50mA (approx.) ● Accessories: 1 Cable with BNC terminals ● Dimensions: W 148 × H 51 × D 225(mm)

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Professor Paul Horowitz, W1HFA, of Harvard University's Physics Department; and Bob Zimmerman, NP4B, of the Arecibo Observatory, for their contributions to this work.

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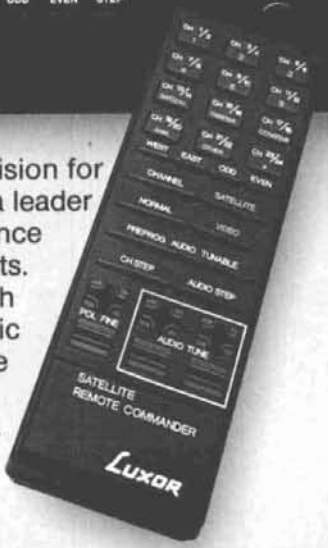

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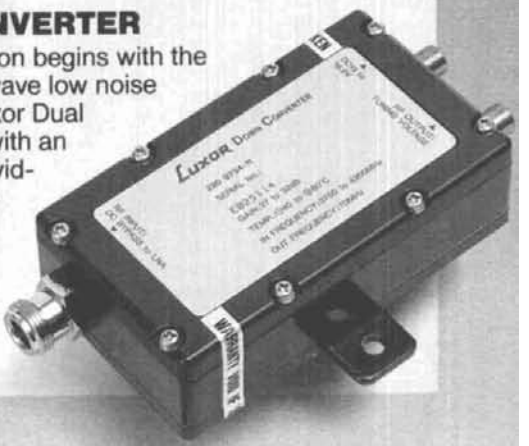

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the weekender

harmonic mixer for VHF signal generation

Lots of useful things that work well can be built without great effort and expense. Unfortunately, until now, a VHF signal generator hasn't been one of them. The cost of parts, the shielding required, and the difficulty of producing a good variable attenuator make designing an inexpensive, easy-to-build VHF signal generator a challenging task indeed.

initial means of generating VHF signals

Even though I was able to use a surplus TS-150 generator to meet my needs from 10 through 400 MHz, I was never fully satisfied with it. Recently when I acquired a pair of Clemens SG-83C solid-state high-frequency signal generators (they're cute and small, and they work well; they'll even work off a 9-volt battery!) at a flea market, my old TS-510 began to look more and more out of place. So the search was on for an up-to-date replacement.

There don't seem to be many bargains among generators that will make it to 400 or 500 MHz. The older units have good precision attenuators with high available output levels up to 480 MHz. But most models are marked by poor stability, excessive signal leakage, and large current consumption. They're contained in large, bulky enclosures, seem to be priced higher than they might be, and depend on exotic, expensive tubes and components. But if you own or have access to a generator in the HF range and want some VHF or UHF coverage without buying yet another generator, you can build this device in just a few hours — for no more than $25.00.

heart of device is diode ring mixer

In recent years the use of diode ring mixers has become increasingly popular in state-of-the-art receiver design. Despite their many advantages, they do present some problems. One is harmonic mixing. Diode ring mixers are LO-driven at high signal levels — typically +7 dBm minimum. These mixers are broadband devices, using wideband transformers and fast hot carrier diodes in their construction; the inexpensive Mini-Circuits SBL-1 DBM used in this article is rated from 500 kHz to 500 MHz at all three ports (see **fig. 1**). When LO power is applied, the diodes are driven into heavy conduction by the RF, producing LO harmonics well into the VHF range and resulting in undesired mixer products from input signals mixing with the harmonics appearing at the IF output port. This required the use of wideband impedance terminations for the DBM ports, as well as HF filters with known stopband characteristics well into the VHF region if the receiver isn't to sound like an aviary at feeding time!

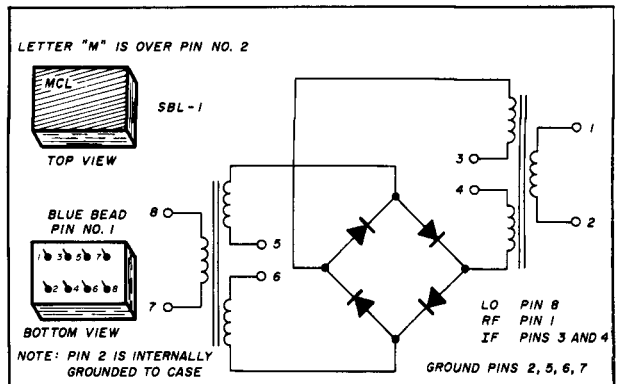
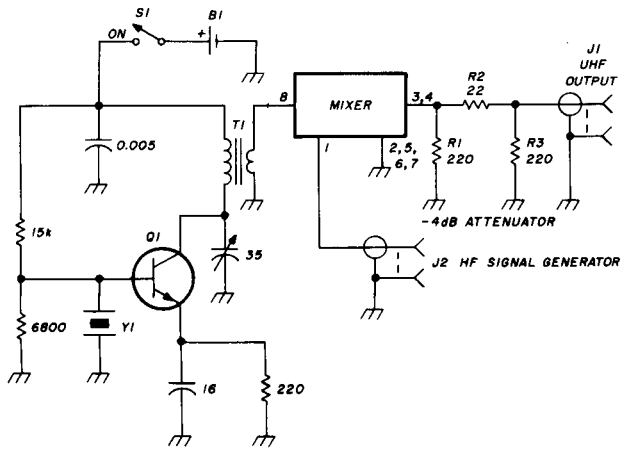


fig. 1. Harmonic generator uses Mini-Circuits SBL-1 mixer.

In this simple adapter circuit we make good use of this phenomenon. Referring to the schematic (see **fig. 2**), note that we are driving the LO port with the output of a 50-MHz overtone oscillator. The oscillator was designed to produce a minimum +10 dBm output with a 9-volt battery supply. DBMs expect to see broadband resistive port terminations if insertion losses, bandwidth, and other parameters are to remain predictable. The RF port of the DBM is connected directly to the HF signal generator output port; most good generators will present a good 50-ohm resistive termination at their output. This is especially true of the Clemens SG-83 series because of the switched pi attenuators employed to set the signal output level. A 4-dB fixed pi attenuator is used at the DBM IF port output. Further attenuation is desirable here; this will be discussed later in the article.

When the device is used at the output of a signal generator, the 50 MHz LO produces internal harmonics in the DBM at 100 MHz, 150 MHz, 200 MHz, etc. throughout the spectrum. When we inject a signal into our adapter from the HF generator, say at 10 MHz,

By Peter J. Bertini, K1ZJH, 20 Patsun Road, Somers, Connecticut 06071



item	description
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S1	single-pole, single-throw miniature switch
T1	primary 12 turns No. 26 wire, secondary 2 turns No. 26 wire
Y1*	3rd overtone 50.0 MHz crystal
mixer	Mini-Circuits Labs (or equivalent) model SBL-1,** 0.5-500 MHz, +7 dBm local oscillator

*50 MHz crystal available from International Crystal Manufacturing Co., 10 North Lee, P.O. Box 26330, Oklahoma City, Oklahoma 73126. Request "general purpose" grade crystal.

**SBL-1 mixer is available from Advanced Receiver Research, Box 1242, Burlington, Connecticut 06013; send SASE for price quote.

fig. 2. Harmonic mixer provides output up to 500 MHz.

outputs at the sum and difference frequencies will result from the 10 MHz signal combining with the 50 MHz LO signal (50 + 10 = 60 MHz or 50 − 10 = 40 MHz) as well as outputs of the sum and difference frequencies of the LO harmonics. From this it is evident that the HF signal generator need only extend to 25 MHz to produce contiguous coverage over the entire range (up to at least 500 MHz) by using either the sum or difference products of the appropriate harmonic. A generator that will go to 50 MHz will allow the output frequency to be determined without involving mental subtraction.

there *are* limitations, though

There is a price to pay for this convenience. First, the conversion losses will vary across the VHF ranges because the LO harmonic amplitudes produced in the DBM are not identical. This is determined by directly comparing the output of the adapter versus the output of a good VHF generator of known calibration into a receiver with signal strength metering for each of the harmonic bands. The receivers should be terminated with an external 6 dB or greater attenuation pad; most VHF receivers present only a reasonable 50-ohm load over a very narrow range of frequencies — (if any).

use is simple

Once the conversion losses are known for the adapter for each of the harmonic ranges, the rest is easy. If you work in the dBm signal levels you need only include the dB loss of the adapter to the dBm reading of the signal generator output. If you prefer to work in microvolts, an easy solution is to employ a separate switched attenuator capable of one dB steps between the signal generator and the adapter. By keeping the adapter losses at 20 dB increments the microvolt scale of the HF generator may be read directly; for each 20 dB of insertion loss the microvolt reading is moved one decimal point to the left.

Spurious responses may be encountered at some desired frequencies when using the adapter. These birdies are easily identified, however, because they tune "backwards" or at rapid rates across the receiver bandpass. Note that when using this adapter, HF signal generator leakage is of minimal importance because it is not the final output frequency. Extremely low MDS measurements can be made, and the conversion loss inherent with this adapter can be advantageous here as some generators (such as my Clemens) are limited to minimum output levels around −120 dBm unless external attenuation is employed.

construction is easy

I built my adapter in a small minibox and used point-to-point wiring techniques on a small square of circuit board, following good VHF techniques such as keeping leads short and using good shielding. I also recommend using the internal battery supply as shown; bringing power leads out of the adapter enclosure is an invitation to stray radiation. The oscillator draws about 10 milliamperes and battery life should be quite long.

The maximum output levels from the adapter are severely limited by the conversion losses, which can be very high on some harmonics, and by the compression that takes place in the mixer if it's overdriven. I've been using my adapter for a few weeks now and I don't know how I ever did without it. The freedom from drift and generator leakage — and ease of setting frequency — are *pure joy*. My old unit is gone.

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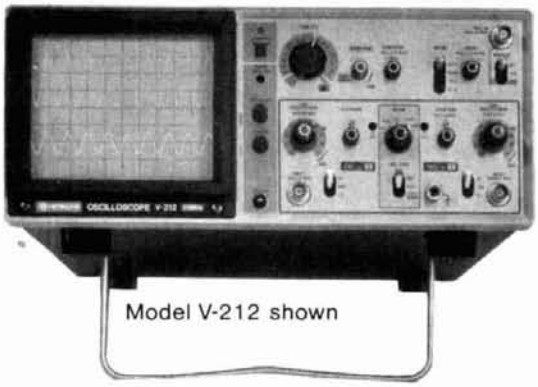

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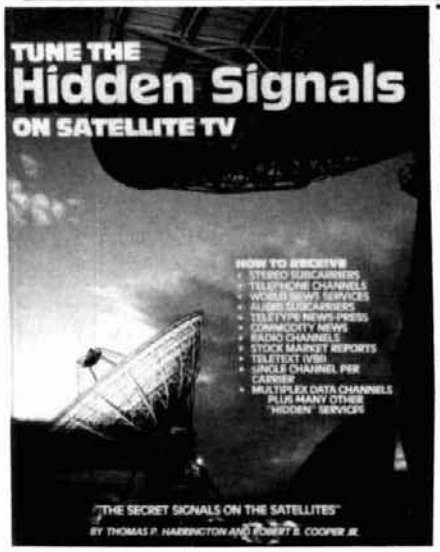

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Selcal (Selective Calling) System: With this feature, the unit only receives messages following a preset code. Built-in Demodulator for High Performance: Newly designed high speed RTTY demodulator has receiving capability of as fast as 300 Baud. Three-step shifts select either 170Hz, 425Hz or 850Hz shift with manual fine tune control of space channel for odd shifts. HIGH (Mark Frequency 2125Hz)/LOW (Mark Frequency 1275Hz) tone pair select. Mark only or Space only copy capability for selective fading. ARQ/FEC features incorporated.
Crystal Controlled AFSK Modulator: A transceiver without FSK function can transmit in RTTY mode by utilizing the high stability crystal-controlled modulator controlled by the computer.
Photocoupler CW, FSK Keyer built-in: Very high voltage, high current photocoupler keyer is provided for CW, FSK keying.
Convenient ASCII Key Arrangement: The keyboard layout is ASCII arrangement with function keys. Automatic insertion of LTR/FIG code makes operation a breeze.
Battery Back-up Memory: Data in the battery back-up memory, covering 72 characters × 7 channels and 24 characters × 8 channels, is retained even when the external power source is removed. Messages can be recalled from a keyboard instruction and some particular channels can be read out continuously. You can write messages into any channel while receiving.
Large Capacity Display Memory: Covers up to 1,280 characters. Screen Format contains 40 characters × 16 lines × 2 pages.
Screen Display Type-Ahead Buffer Memory: A 160-character buffer memory is displayed on the lower part of the screen. The characters move to the left erasing one by one as soon as they are transmitted. Messages can be written during the receiving state for transmission with battery back-up memory or SEND function.
Function Display System: Each function (mode, channel number, speed, etc.) is displayed on the screen.
Printer Interface: Centronics Para Compatible interface enables easy connection of a low-cost dot printer for hard copy.

Wide Range of Transmitting and Receiving: Morse Code transmitting speed can be set from the keyboard at any rate between 5-100 WPM (every word per minute). AUTOTRACK on receive. For communication in Baudot and ASCII Codes, rate is variable by a keyboard instruction between 12-300 Baud when using RTTY Modem and between 12-600 Baud when using TTL level. The variable speed feature makes the unit ideal for amateur, business and commercial use.
Pre-load Function: The buffer memory can store the messages written from the keyboard instead of sending them immediately. The stored messages can be sent with a keyboard command.
"RUB-OUT" Function: You can correct mistakes while writing messages in the buffer memory. Misspellings can also be erased while the information is still in the buffer memory.
Automatic CR/LF: While transmitting, CR/LF automatically sent every 64, 72 or 80 characters.
WORD MODE operation: Characters can be transmitted by word groupings, not every character, from the buffer memory with keyboard instruction.
LINE MODE operation: Characters can be transmitted by line groupings from the buffer memory.
WORD-WRAP-AROUND operation: In receive mode, WORD-WRAP-AROUND prevents the last word of the line from splitting in two and makes the screen easily read.
"ECHO" Function: With a keyboard instruction, received data can be read and sent out at the same time. This function enables a cassette tape recorder to be used as a back-up memory, and a system can be created just like telex which uses paper tape.
Cursor Control Function: Full cursor control (up/down, left/right) is available from the keyboard. Test Message Function: "RY" and "QBF" test messages can be repeated with this function.
MARK-AND-BREAK (SPACE-AND-BREAK) System: Either mark or space tone can be used to copy RTTY.
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Audio Monitor Circuit: A built-in audio monitor circuit with an automatic transmit/receive switch enables checking of the transmitting and receiving state. In receive mode, it is possible to check the output of the mark filter, the space filter and AGC amplifier prior to the filters.
CW Practice Function: The unit reads data from the hand key and displays the characters on the screen. CW keying output circuit works according to the key operation.
CW Random Generator: Output of CW random signal can be used as CW reading practice. **Bargraph LED Meter for Tuning:** Tuning of CW and RTTY is very easy with the bargraph LED meter. In addition, provision has been made for attachment of an oscilloscope to aid tuning.
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designing low voltage power supplies

Husky power supply delivers 15 amps at 13.8 volts

Power supplies for tube equipment used to be fairly simple devices, easily assembled from parts found in any handy junk box and quite forgiving of design error. But low-voltage regulated supplies for solid-state gear are something else again.

Poorly designed low-voltage supplies can create instability of transmitted signals, distortion of received signals, hum, noise, spurious emissions and transients. A well-designed supply, on the other hand, contributes greatly to clean, trouble-free station performance.

specifications

At the heart of any power supply is the transformer, which takes energy from a commercial power line and converts it to some specified lower or higher voltage at a specified current. The single most expensive unit in the whole assembly, the transformer is usually called upon to absorb more abuse than any other component. Once you've specified the transformer, you've almost specified the rest of the supply.

Because the transformer is the most expensive component, it's also the one in which manufacturers may tend to cut corners. Sometimes they'll put a 2-ampere transformer in a box with a few other components and advertise the result as a "5-ampere power supply."

choosing the transformer

The three principal specifications for the transformer are primary voltage, secondary voltage, and maximum secondary current. To specify the secondary requirements, you must first decide how much filtered DC current and voltage you want. For the sake of illustration, let's walk through the process of designing a supply that will deliver about 15 amperes at 13.8 volts continuously and about 20 amperes intermittently, since that sort of supply would handle most ham station requirements.

Fortunately, most manufacturers rate their transformers for continuous service. Transformers are bulky objects with a lot of thermal inertia; they can absorb a lot of heat without getting hot too quickly. Consequently, a transformer rated at 10 amperes continuous duty can probably deliver about 14 amperes or more on a 50-percent duty cycle and perhaps even more current on a shorter cycle without serious risk.

Perhaps the most severe duty most ham stations impose on a power supply (aside from beacon or repeater duty) is a long-running activity such as the ARRL Sweepstakes or the *CQ* WW contest. In contests, operators listen at least as much as they transmit, automatically setting the duty cycle at 50 percent or less. An overloaded transformer can rest and cool off during the time it is not required to deliver power to the transmitter.

If you're operating CW, the key will be down and the transmitter putting out only about half the time you're in the transmit mode, so your net duty cycle is down to 25 percent. And if you're working SSB, the duty cycle is even lower.

So if an HF rig demands 20 amperes key down,

By George L. Thurston, III, W4MLE, 2116 Gibbs Drive, Tallahassee, Florida 32303

what's needed is a power supply that will handle about 25 percent of that or 5 amperes continuous, right?

Wrong!

Heat generated by internal losses is the biggest enemy of transformers. These losses rise steeply as the current demand exceeds capabilities. The losses have several causes:

- The ohmic resistance of the windings is a major source of heat generation, especially at high currents, because heat (power) equals I^2R. When you double the current in a winding, you quadruple the heat. As copper gets hotter, its resistance increases still further.
- Eddy currents, induced in the iron core of the transformer, generate heat. The larger the current in the windings, the larger the eddy currents. These losses can be minimized by careful design of the transformer by the manufacturer.
- Hysteresis losses also generate heat. They result from the use of some transformer energy to jostle iron atoms in the core, magnetically exciting them. Simply put, energy is lost in rearranging the magnetic patterns in the core.
- Dielectric losses occur in a transformer because it is inherently a capacitor as well as a transformer; it is several masses of metal in close proximity, separated by insulation. The insulating dielectric is usually quite lossy; heat is generated by jostling its molecules around in the rapidly-changing electrostatic fields inside the transformer.

This means that you *can* run a transformer harder than its continuous-duty rating, but only within certain limits. Even if you could keep the transformer cool, hysteresis, eddy current and ohmic losses would severely degrade performance.

Generally, however, it is reasonable to expect about 40 percent more — at most — than the continuous rating. So, if a rig wants 20 amperes key down, we can get away with using a transformer rated at 12 amperes continuous duty. But a 15-ampere rating would be safer and cooler and would pose a smaller risk of failure.

overall design

Since abrupt changes in supply voltages can cause trouble in electronic gear, a power supply must be stiffly regulated, varying output voltage 0.1 percent or less when the load goes from open circuit (no current) to the design limit of the supply (20 amperes). Such regulation is easily obtained with inexpensive parts. In addition, we must have DC with the AC ripple component reduced to an insignificant level.

Because both cost and performance are concerns, this design will be fairly conservative, without much consideration of size and weight.

For simplicity, we'll use a conventional series-pass transistor circuit controlled by an electronic regulator. That means that the DC output from the filter will have to be somewhat higher than the desired regulated voltage. Most electronic regulators require 2 or 3 volts difference between input and regulated output. Since we want 13.8 volts regulated, we'll need at least 16.3 volts out of the filter at full load for reasons that will soon become apparent.

One rule of thumb says that under load, a power supply will deliver a DC output about equal to the applied RMS voltage for a full-wave bridge, or about half the total secondary voltage in a center-tap circuit. Actually, 90 percent of the RMS voltage is a bit more accurate if the transformer is taxed to its full load limit. Thus, an 18-volt secondary will deliver about 16 volts DC ($0.9 \times 18\ V_{RMS}$) under full rated load. But with no load, the DC output voltage will approximate the AC peak voltage, which is $1.414 \times V_{RMS} = 25.5$ volts. Using the same formula, you can see that a 30-volt secondary will deliver about 42 volts at no load — too high for our regulator chip, whose maximum input rating is 35 volts. The maximum RMS output we can tolerate will be 35 volts $\div$ 1.414 = 25 volts.

So our transformer must have a secondary that gives us between 19 and 25 volts AC RMS at about 15 amperes continuous. If the transformer is center-tapped, for use with only two diodes, we need that much voltage on either side of center. If we're using a bridge, we need only a single winding delivering the desired voltage.

Let's assume that our junk box contains a 12.6-volt filament transformer rated at 15 amperes, and that we can scrounge a 6.3-volt filament transformer rated at 20 amperes. Connecting primaries in parallel and secondaries in series so that their voltages add, we get 18.9 volts RMS AC. The amount of current we can draw at that voltage is limited by the lower rating — 15 amperes. But because the output voltages from the two secondaries will not be precisely in phase (because of differences in manufacturing), we must derate their current capacity by about 10 percent. So we can demand only 90 percent of 15 amperes, or 13.5 amperes from the power supply on a continuous basis, or about 19 amperes intermittently. Given the uncertainties involved in estimating duty cycles and the amount of uprating and derating, that should be close enough.

So we can expect to get about 17 volts at full load and about 27 volts at no load from the rectifier-filter output.

selecting rectifiers

Because we chose a transformer without a center-tap, we'll need to rectify the AC with a full-wave bridge. Radio Shack and other suppliers offer an in-

expensive bridge rated at 25 amperes at 50 volts peak inverse voltage (PIV).

In a bridge circuit, the full transformer secondary voltage appears at the nonconducting anodes. Since our transformer secondary voltage is 26.9 volts peak, the 50 PIV rating (also sometimes called the peak *reverse* voltage, or PRV) is quite satisfactory, but not extreme. Discrete diodes could also be used in a bridge circuit, of course, with each rated to handle at least half the total load current with a PIV above the peak output voltage of the full secondary winding of the transformer. For this supply, diodes rated at 50 PIV and 10 or 15 amperes each would be satisfactory.

choosing the regulator

In any power supply the filter immediately follows the rectifiers. But in a regulated power supply, the choice of regulator circuit is intimately connected with design of the filter for reasons that will soon become clear.

The regulator samples the output voltage of the power supply, compares it to a fixed reference voltage, detects any difference, and applies a correction voltage somewhere in the circuit to counteract any change in output voltage.

The earliest and simplest regulators used a zener diode for a reference and simply applied that voltage to the base of a pass transistor, clamping the output at approximately the zener voltage (**fig. 1**). This circuit was quite a big improvement over the zener diode alone for two reasons: first, as a series, rather than shunt regulator, it could handle a lot more current; second, it offered a rudimentary sort of "electronic filtering." If a capacitor is connected between the base and ground, its filtering effect (capacitance) will be multiplied by the β of the transistor. Thus, if the transistor is a 2N3055 with a typical β of about 70, it would make a 100 μF capacitor do the filtering job of a 7000 μF capacitor.

The disadvantage of this circuit is that it provides no feedback loop. When power is taken from the emitter, a voltage drop occurs across the silicon emitter-collector junction and across any DC resistance in wires and connectors. Such a "regulated" supply's output may easily drop several volts under a heavy load. That's not good regulation!

Another circuit frequently seen even now in magazine articles is basically the same as above with an IC regulator chip substituted for the zener (**fig. 2**). It has exactly the same disadvantage as the zener circuit — no feedback loop. The IC chip will hold the base voltage very tight but it has no control of the voltage at the load.

Another circuit, using a zener diode and discrete components, is a considerable improvement over the others (**fig. 3**). In this circuit, the zener serves as a reference, and the base of a regulator transistor samples the output from the supply. Any change in the ratio between the zener reference voltage and the base voltage is converted into an error signal at the emitter and is applied to the pass transistor.

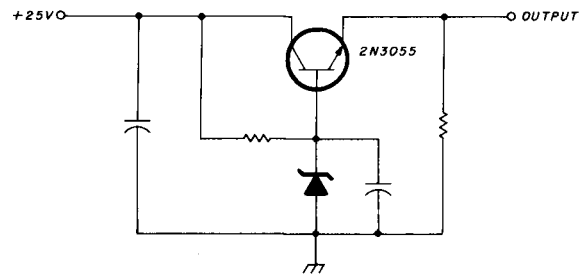


fig. 1. Basic voltage regulator using a zener diode and pass transistor. Disadvantage of this circuit is that it provides no feedback loop.

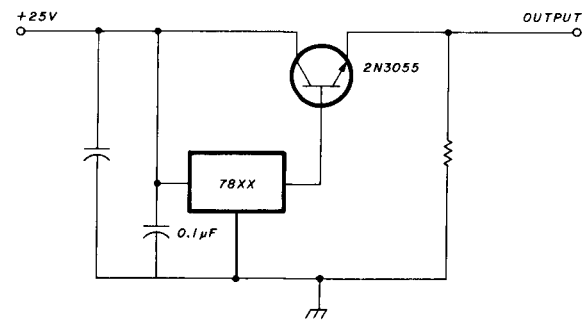


fig. 2. Regulator circuit using an IC chip in place of the zener. Circuit also has no feedback loop; IC chip regulates the base voltage but has no control of overload voltage.

A further embellishment of this idea (**fig. 4**) is to apply the error voltage to a driver transistor that also serves as an error amplifier, Q2, resulting in high sensitivity and good regulation. The regulator transistor, Q1, can be quite small (a 2N2222, for example) but the driver must be able to handle the base drive current required by the pass transistor, Q3. With suitable transistors, this circuit should be able to maintain load regulation of better than 1 percent.

three-terminal regulators

Properly used, however, the integrated circuit regulator chips can put us into a whole new ball park of regulation — 0.1 percent or even 0.01 percent with off-the-shelf parts.

The circuit in **fig. 5** shows a 78XX regulator with

a PNP "wrap-around" pass transistor.[1,2] The regulator chip and the pass transistor share the load current in a ratio set by resistors R1 and R2. Any change in the load voltage is sensed internally by the chip and applied to its input where it is also applied to the base of the pass transistor. The diode simply increases the voltage differential between input and output by the amount of the silicon junction voltage drop.

With the proper pass transistors, this circuit can deliver almost any practical amount of current. To use NPN transistors requires a PNP driver stage between the regulator chip and the bases of the pass units to provide the correct bias voltage polarity. This sort of circuit is shown in **fig. 6**.

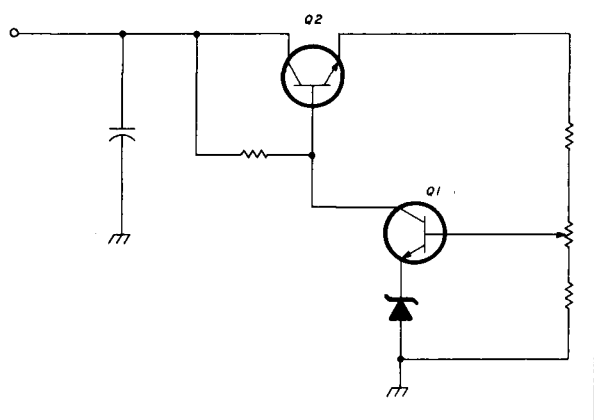


fig. 3. Regulator circuit in which the zener is a reference and base of regulator transistor, Q1, samples supply output.

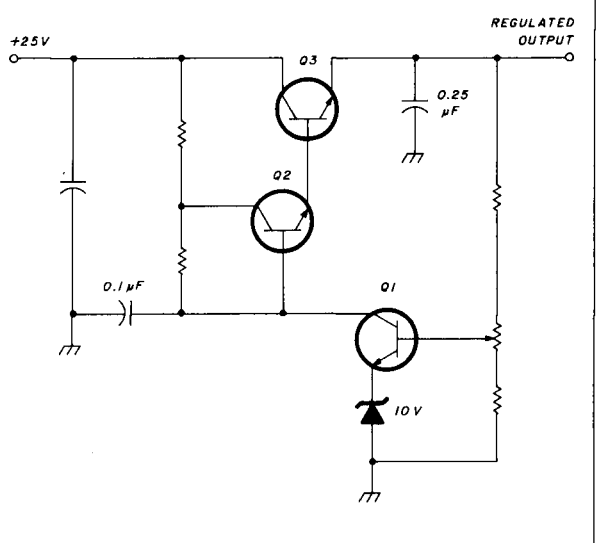


fig. 4. Improved regulator uses a 2N2222 regulator transistor. TIP-31 driver-error amplifier, and 2N3055 pass transistor. Regulation better than 1 percent can be obtained.

Both the circuits of **figs. 5** and **6** produce voltage regulation on the order of 0.1 percent. The more sophisticated LM-723 regulator chip, with a higher parts count required in its circuitry, is capable of regulating a whole order of magnitude better than the 78XX regulators; about 0.01 percent is typical. The circuit shown in **fig. 7** is representative, but there are some trade-offs.

The 723 can deliver only about 150 mA at the regulated output voltage and so requires a driver stage for most pass transistors. It also requires a rather long parts list and, unless carefully shielded and bypassed, is often subject to RF interference that causes it to operate erratically. One redeeming feature is that its voltage-sensing connections are isolated and can be connected directly to the load by a long run of small wire. This permits the regulator to compensate for voltage drops in the wiring to the load.

Like the 78XX chips, the 723 offers automatic shutdown if it gets too warm or if excessive current is drawn from the supply. A short circuit across the output terminals of even a 50-ampere supply produces only a minor spark and a turn-off of the voltage. The voltage recovers to normal when the short circuit is removed, with no harmful effect. Over-voltage and over-current protection circuits are discussed later in this article.

After considering all the possibilities, we have decided to use the circuit of **fig. 6**, permitting us to use NPN transistors, inexpensive, readily-available regulator chips, and a minimum of external parts.

the 7812 regulator

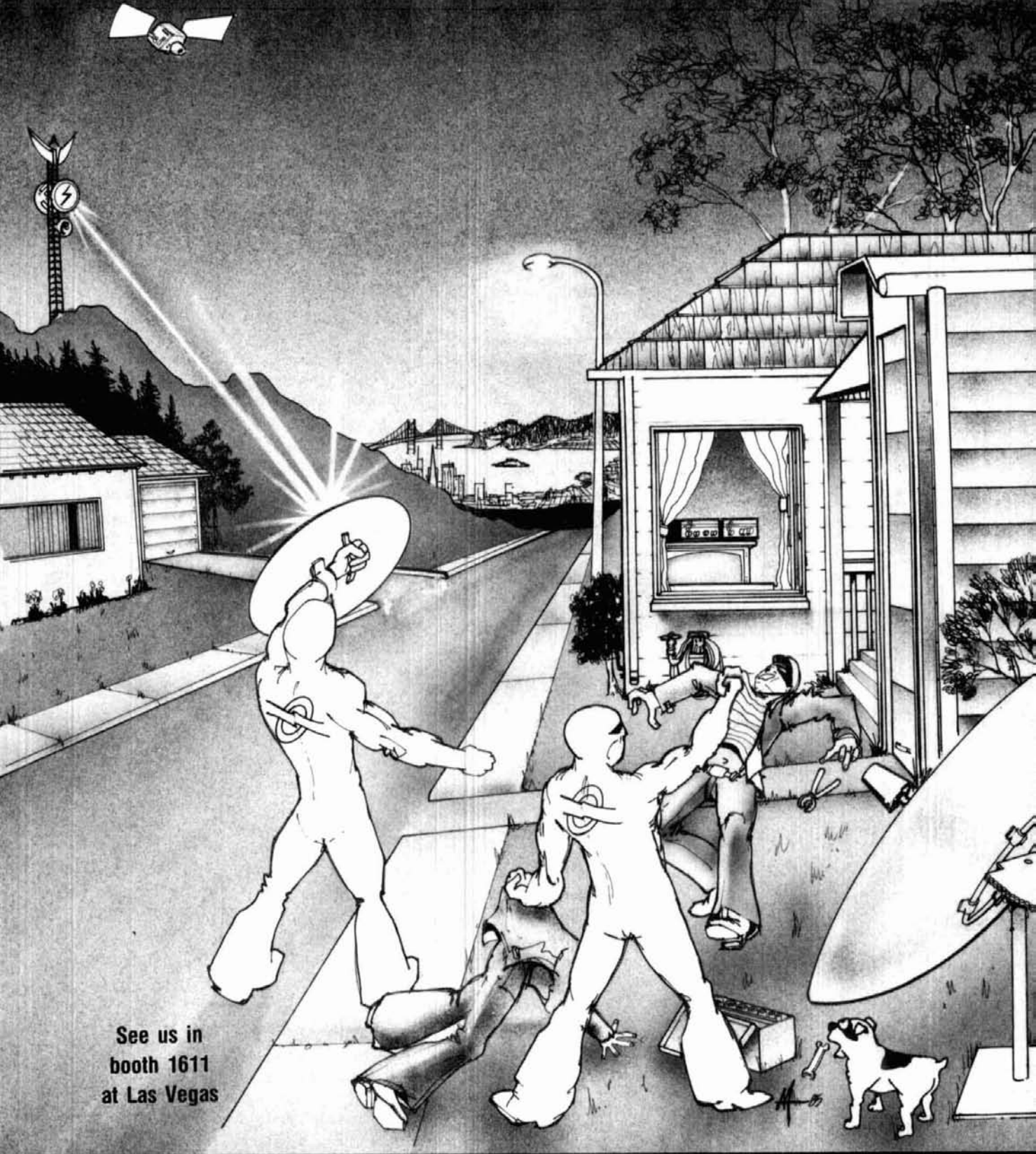
Many good regulator IC and discrete-component circuits are available to Amateur builders and many of them offer excellent regulation. The LM-723 offers 0.01 percent regulation of both line and load, but at the expense of fragility and added circuit complexity.

Line regulation is the percentage of output voltage change with a change in power line voltage. Load regulation is the percentage of output voltage change with a change in the load current.

For virtually all but laboratory purposes, 0.1 percent regulation is more than adequate and is readily attainable with simple circuits and inexpensive components.

Since we're building what amounts to a fixed-voltage supply, we can eliminate most of the IC regulators that provide adjustable output such as the LM-317, the LM-350, and the LM-723.

Members of the 78XX series, on the other hand, are adjustable within limits, can deliver more than an ampere of regulated output, require very few external components, and provide regulation better than 0.1 percent. (The 7812 regulator is used in our finished power supply.) In addition, they have internal short-



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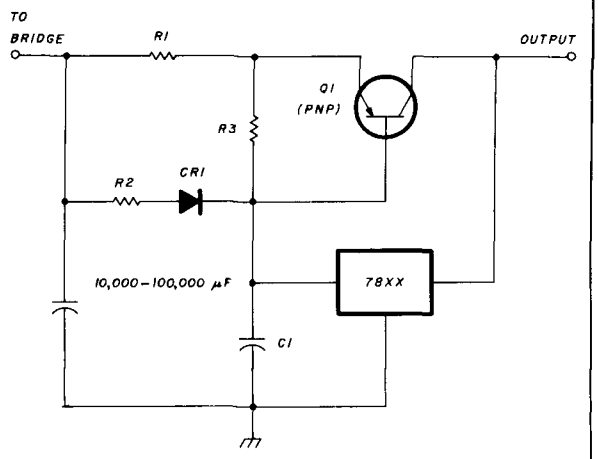


fig. 5. A 78XX regulator with a PNP "wraparound" pass transistor. Regulator IC and pass transistor share load current in the ratio set by R1 and R2.

circuit protection, internal over-heating protection and can lend these properties to the pass transistors as well. These chips have a ripple rejection of better than 50 dB and require an input only about 2.5 volts above their regulated output. The regulated output voltage is adjustable within limits by inserting a resistor in the ground lead. That's a lot of regulator for a couple of bucks!

designing the filter[1-3]

The requirement of a 2.5-volt differential between input and regulated output sets the dropout voltage. That's the input voltage below which the regulator chip loses control. At the dropout voltage, any further reduction in the input produces a similar reduction in the output.

The dropout figure is the reason we deferred design of the filter until the regulator was chosen. What does that have to do with filter design? Plenty. Any AC ripple voltage on the regulator input makes the instantaneous voltage rise and fall at a 120-Hz rate. The larger the ripple voltage, the greater the peak swings of the input voltage. If the input dips below the dropout value on those negative peaks, the regulated output also drops, introducing ripple into the output.

Obviously, we need filter design that will keep the negative ripple peaks above the dropout voltage.

Since we want an output voltage of 13.8 volts, we'll select a 7812 regulator chip and raise its voltage with a resistor in the ground lead. And because data sheets for the 7812 put the input dropout voltage at about 2.5 volts, we must supply an input voltage of at least 16.3 volts; that is, *the input voltage must never fall below 16.3 volts* or ripple will appear in the output.

We have already determined that the output voltage of the rectifiers and filter will be 17.0 volts under full load. How much ripple can we tolerate without going into the dropout zone? The difference between 17.0 volts and 16.3 volts is 0.7 volt, which is the value of the negative *peaks* we can tolerate. That would give us 2 × 0.7 volt or 1.4 volts peak-to-peak, as the maximum tolerable amount.

How much capacitance do we need between the bridge output and ground to limit ripple to this amount? All recent editions of the ARRL *Radio Amateur's Handbook* explain the problem in detail. In short, for a ripple frequency of 120 Hz, the required capacitance in μF would be:

$$C_{\mu F} = \frac{I \times 8.3 \times 1000}{E}$$

where I is the load current and E is the peak-to-peak ripple voltage. In our supply, I = 20 amperes and E = 5.2 volts. The required capacitance would be 118,571 μF.

As a matter of economics, a commercial manufacturer might choose a 120,000 μF capacitor or choose to use a higher input voltage to reduce the required capacitance. The purpose of the design computation, of course, was to determine the *minimum* permissible amount of filtering. But a savvy Amateur would use more than the minimum — probably at least 150,000 μF. Such values are easily obtained by paralleling computer surplus units purchased at hamfests or from mail-order suppliers or obtained from a friend's junk box.

Since the maximum amount of allowable ripple

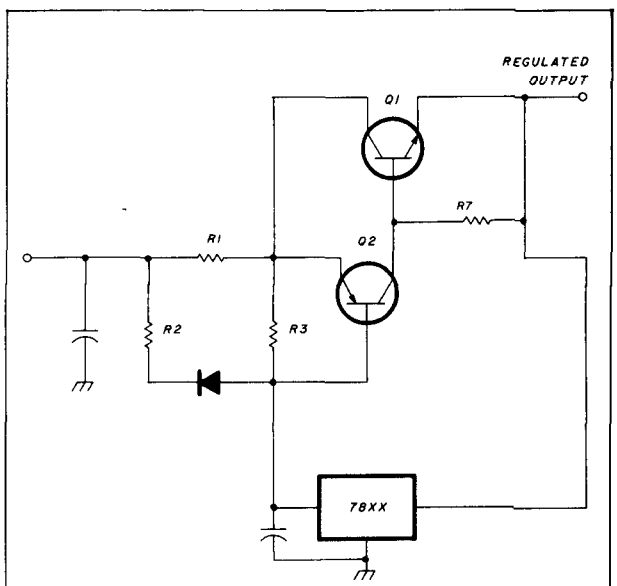


fig. 6. Another version of the 78XX regulator using an NPN pass transistor. A PNP driver stage provides correct bias voltage polarity. Voltage regulation of this circuit and that of *fig. 5* is of the order of 0.1 percent.

determines the amount of filter capacitance required, the problem could also be attacked by increasing the input voltage to the regulator, thus increasing the allowable ripple level. This can be done simply by using a transformer with a higher output voltage, with the trade-off that the pass transistors will have to dispose of more excess voltage, thus dissipating more heat.

A more sophisticated way to get the best of both methods is used in some Astron commercial power supplies, among others. An example appears in **fig. 7**. Here additional taps on the transformer secondary provide higher voltage at low current to operate the regulator chip while the lower-voltage, high-current winding operates the pass transistors and supplies the main output.

In the circuit shown, the regulator chip (an LM-723) takes its input from the higher-voltage supply that is separately rectified and separately filtered. Because the load impedance on this supply is quite high (small load current compared to the input voltage) it is quite easy to filter well, and the higher voltage input allows even greater leeway with the ripple content.

The highly-filtered input to the regulator chip could also be provided by a separate transformer, avoiding the need for a specially-wound transformer such as those found in some commercial units.

Separate regulator supplies cannot be used with the 78XX wraparound regulator circuit we have chosen for our example supply, however.

choosing a driver stage

In our chosen circuit, we need a PNP driver between the regulator chip and the pass transistors to invert the polarity of the error-voltage changes. In other circuits we might also need a driver to supply sufficient base drive to the pass elements, as in **fig. 7**, for example. But how much drive current do we need?

The answer lies in our choice of pass transistors. We will use two 2N3055s to deliver 20 amperes. The β of these transistors typically is about 70. Twenty amperes divided by 70 is 0.286 ampere, which is the amount of drive current we need. But to be on the safe side, we'll choose a transistor that will deliver at least twice that amount. It happens that an ECG 129 will handle 1 ampere of collector current and has a β of about 100. It is an inexpensive, readily-available PNP transistor and so would make a good choice.

In heavier supplies, or when it is necessary to drive less sensitive pass transistors, thus requiring more base drive than 1 ampere, it will be necessary to use a heftier driver transistor. The Darlington PNP IC designated TIP-125 will deliver up to 5 amperes of drive current and, because it has a β of at least 1000, the drive it requires from the regulator is very small indeed. Thus the TIP-125 could be used with such regulators as the LM-723 and the 78LXX series, which deliver only about 100 mA of regulated output.

choosing pass transistors

Pass transistors are the "valves" that control the flow of current from the rectifiers to the load, and they act much as though they were variable resistors in series with the load. They must absorb all the power supply energy not taken by the load. In our case, they must absorb a voltage drop of 3.2 at 20 amperes under full load = 64 watts.

For our pass transistors, we'll select the readily-available, rugged, and inexpensive 2N3055 NPN silicons rated at 115 watts each and 15 amperes maximum collector current. They have a forward current transfer ratio (h_{FE} or β) of about 70. They cost less than $2 each at discount houses and hamfests, and often sell for a fraction of that.

One 2N3055 would handle the full heat load from our power supply — only 64 watts — but one transistor can't handle the 20 ampere maximum current we want to draw.

We can overcome this by connecting two pass transistors in parallel, providing 30 amperes capability. But they can't simply be connected in parallel because all semiconductor devices are slightly different: one transistor, with the higher β, would try to take all the current, leaving little on none for its mate. This is easily corrected with low-value resistors in each collector load, allowing the current to equalize. Power dissipated in each 0.1-ohm resistor equals I^2R where I = half the total load current (the current through each transistor). Since in this case I = 10, I^2 = 100 and P = 10 watts.

However, it probably is not necessary to use 10-watt resistors because I = 10 only when the key is down or voice peaks are maximum. The *average*, even in CW, will probably be about 5 amperes. At that level I^2 = 25 and P = 2.5 watts. Most likely a 5-watt resistor will work fine. Resistors, like transformers, have a relatively large thermal inertia because of their mass — a wholly different situation than prevails in semiconductors, which will fail immediately when their maximum ratings are exceeded.

Exact resistance values are not critical in the emitter-equalizer applications so long as they equal each other and offer a very low voltage-drop at maximum current. Two 5-watt resistors in parallel could be used in place of a single 10-watt resistor.

heat sinking[3-11]

Transistor junctions, even in big power transistors, are very small devices: they have little mass, hence low thermal inertia. In other words, they get hot almost instantly, even in normal use. Power transistors are packaged in cases designed to dissipate this heat; they partly make up, by their own bulk, what the silicon junction lacks in mass. That's why the collectors on most power transistors are connected to the metal case of a TO-3-type package and to the tab of a

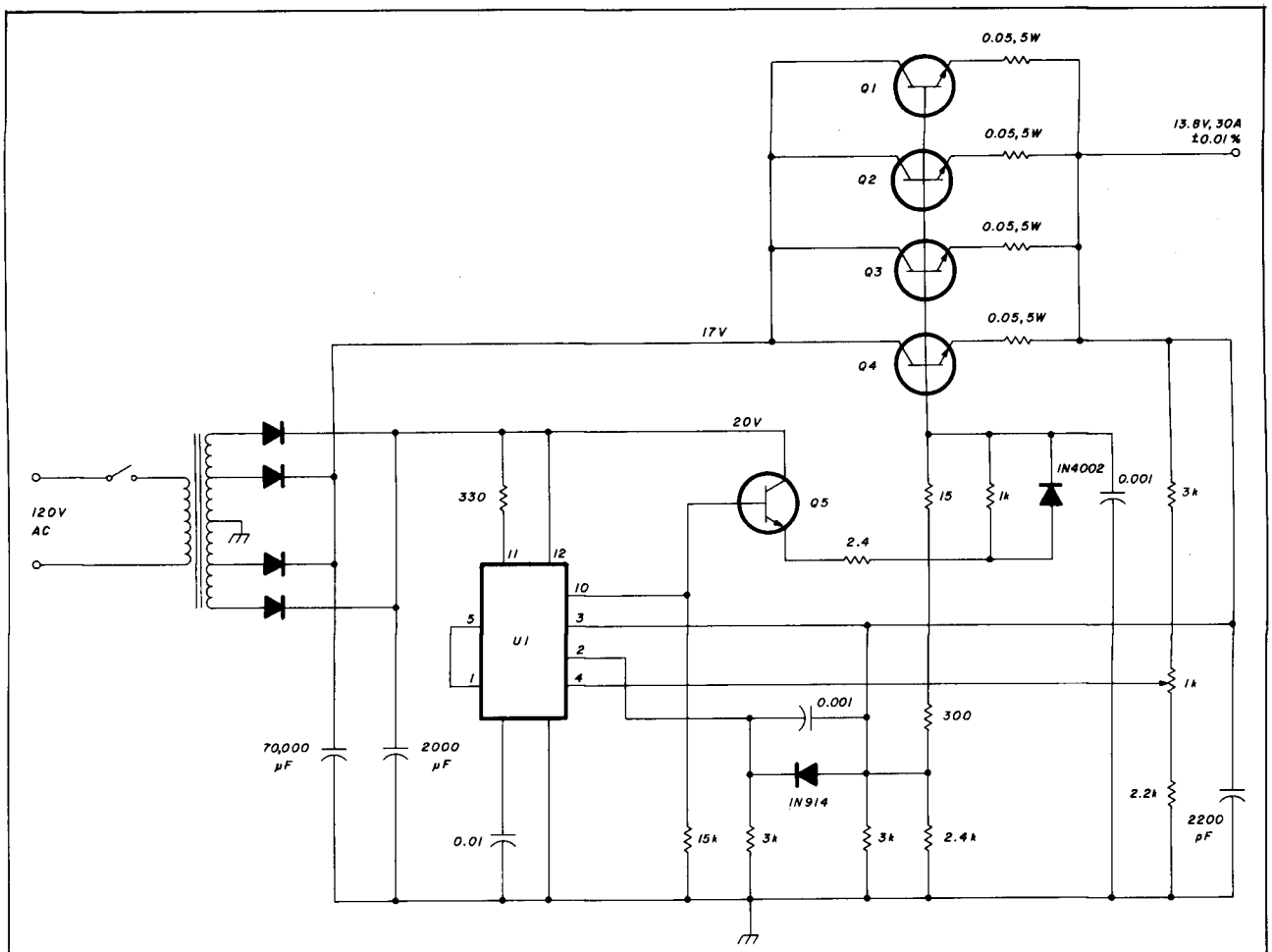


fig. 7. Simplified diagram for Astron RS-35M power supply.

TO-220-type package. The collector generates most of the internal heat because it must carry all the emitter current plus all the base current.

External heat sinks are large masses of metal, such as aluminum or copper, that are highly conductive of heat and have a large surface area to help transfer that heat to the surrounding air. A lot of complex formulas exist for calculating the necessary amount of heat sinking.[3-11] They take into account the mass of the heat sink, the temperature of the surrounding air, and the degree of thermal coupling between the transistor case and the heat sink.

Use these formulas if you like, but a Sylvania shop note offers a better practical suggestion: "Use the biggest heat sink you can find that will fit into the space available."

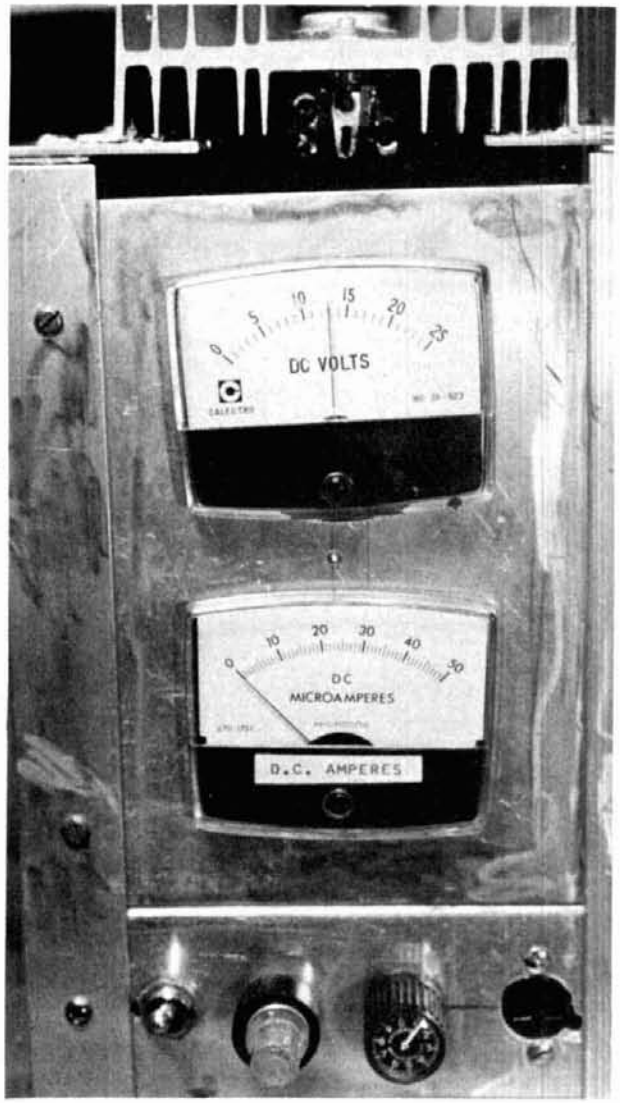
The pass transistors obviously need a large amount of heat sinking because they must dissipate a large amount of heat at maximum current. So do the rectifier diodes or bridge.

The regulator chip and driver transistor will also perform better and last longer if they are used with an adequate heat sink. Power resistors, used in several places in the circuit, don't need heat sinks, but they should be mounted on top of the chassis where air can circulate around them.

stabilizing the regulator

Regulators, whether they are IC chips or discrete components, are high-gain amplifiers and thus are subject to self-oscillation unless precautions are taken to prevent it.

Sometimes such suppression is quite easy and sometimes it requires a great deal of experimentation. But no regulated power supply should be put into service until it has been given a thorough test for oscillation, preferably using an oscilloscope connected across the output terminals of the supply. Oscillations, usually in the 10 kHz to 10 MHz range, will appear as thickening of the trace even if they are not resolvable into individual cycles. Another test option would be to use an RF probe with a VTVM. The meter should



Front panel of 50-ampere power supply. Power ON/OFF switch is at bottom left. Fuse holder is next (with neon lamp to indicate blown fuse). A 10-turn pot is used to adjust voltage. A 2-pin Jones plug (lower right) provides output voltage for small loads.

show no output at all if the power supply is stable, and will give readings of probably several volts if oscillations are present.

The supply may be stable at no load, but break into oscillation at some values of load current while remaining stable at other values. It is necessary to apply several different loads while checking for oscillations to be sure the supply is stable. A good range would be 10 percent, 50 percent, and 110 percent of the rated capacity of the supply.

A standard precaution to observe during construction is to return all ground leads to a single point in order to avoid ground loops. A suitable point would be the negative terminal of the filter capacitor. This would be connected to the chassis by a heavy conductor leading directly to the output terminal and grounded there. This connection must be made with wire heavy enough to handle the entire rated output of the power supply without significant voltage drop. Two or three pieces of flexible copper braid from RG-8 coax would be suitable for a 30 or 40-ampere supply. Cables sold for automobile battery connections are also usually adequate.

All 78XX regulators must be bypassed directly from the input pin to the control pin by a 0.1 μF capacitor connected right at the terminals of the device. Ordinarily, this is enough; however, it sometimes occurs that the inverter/driver transistor or the pass transistor(s) or combinations of both will oscillate. This is especially true if leads are longer than an inch or two between these devices and the IC regulator or between transistors. In most supplies, these leads are much longer than that because of the sheer physical size of the components.

The cures are usually found by cut-and-try. Try bypass capacitors of 0.01 to 1.0 μF. Disc ceramic, metal film, solid tantalum, electrolytic or Mylar are suitable, but capacitance values of electrolytics should be in the 2-10 μF range. Try first bypassing base connections right at the transistors. In a parallel-pass-transistor circuit, try bypassing one transistor but not the others, thus unbalancing any push-pull oscillation.

If bypassing bases doesn't work, try bypassing emitters or collectors. If necessary, insert 100-ohm resistors in series with base connections and bypass one end of the resistors. But don't use resistors in high-current leads, or substitute driver or pass transistors of lower β, for obvious reasons.

The supply may be considered stable if it generates no oscillations at any load within its rated output, even when the load is switched on and off rapidly and repeatedly.

RF sensitivity

Another potential source of instability in a power supply is sensitivity to strong RF fields produced by local transmitters. This is not self-oscillation, but it can exhibit some of the same symptoms — loss or degradation of regulation. With either external RF or internal oscillations, it is not uncommon to see the voltage *rise* when a load is applied.

The cure for this problem is to keep RF out of the power supply. It is most troublesome at the very low-level stages — the regulator chip or transistor. In extreme cases, enough RF may be present to upset a pass transistor or driver.

Enclosing the power supply in a metal cabinet is simple and usually the only RF protection necessary, especially if the cabinet is connected to the station ground. The next simple, obvious step is to bypass AC leads to the chassis and to each other where they

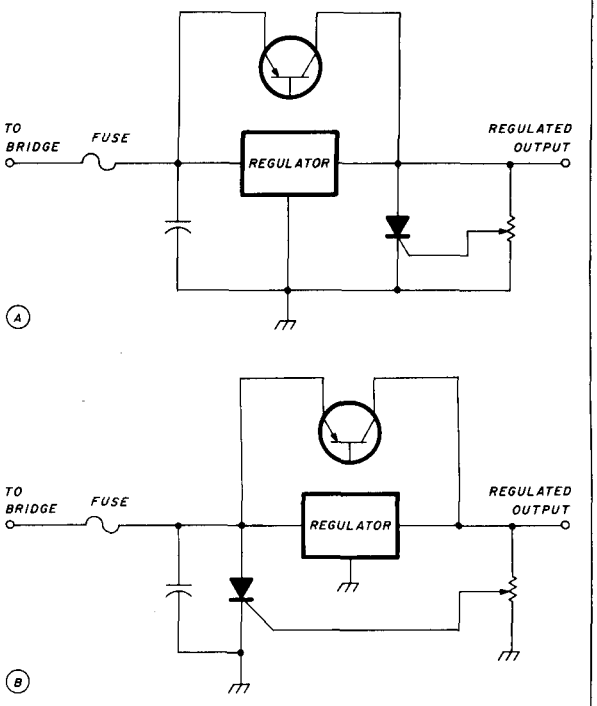


fig. 8. Crowbar circuits using SCRs. In (A) if the regulator fails, the overvoltage will continue to pass excessive current to ground with possible destruction of the SCR, transistors, and transformer. In (B), the SCR is connected across the filter capacitor so that if an overvoltage occurs the short circuit merely blows the fuse.

enter the cabinet. The core of the transformer should also be grounded, along with its internal Faraday shield (if it has one). Suitable AC line bypasses would be 0.02 to 0.05 μF at 600 volts or more.

The output should also be bypassed by capacitors of 0.05 to 0.25 μF because the leads taking power to the load can act as an antenna, feeding RF back into the supply. In aggravated cases such as might occur when operating with a high VSWR, with high RF voltages all over the station, it may be desirable to enclose the regulator chip in an RF-tight metal box within the power supply cabinet, with leads entering and leaving through 0.005 μF feed-through capacitors.

Such extreme measures will seldom be necessary, but it is well to be aware of available curative methods should problems arise.

overvoltage protection[12-19]

If a regulator chip were to fail or if a pass transistor were to short, the result would be that the full output of the bridge would appear at the output of the power supply, with dire consequences for any 12-volt solid-state equipment connected to it.

One common means of protection against this potentiality is a "crowbar circuit." Its usual arrangement includes a silicon-controlled-rectifier (SCR) rated to handle at least the full rated output current of the power supply. The trigger of the SCR is connected to the wiper of a potentiometer connected across the regulated output of the supply. The potentiometer is adjusted so that if the output voltage rises above some predetermined value — usually about 15 volts — the SCR is triggered into conduction, becoming, in effect, a short circuit or "crowbar."

In many commercial supplies, the crowbar is applied directly across the regulated output of the supply. The theory is that this will actuate the automatic overcurrent shutdown feature of the regulator chip, thus shutting off the supply.

It's an excellent theory and it works fine in practice as long as the regulator chip works. But if the primary cause of the overvoltage is failure of the chip, there's a good chance that it won't shut down, either. The result is that the overvoltage continues to jam excessive current through the SCR to ground, with probable destruction of the pass transistors, possible destruction of the SCR and possible damage to the transformer itself (see **fig. 8A**).

A much safer procedure is to connect the SCR across the filter capacitor, following a fuse or circuit breaker rated slightly above the maximum allowable current from the supply. Then, when an overvoltage triggers the SCR (with the trigger still connected to the pot across the regulated output), the short circuit merely blows the fuse (**fig. 8B**). Note that if the filter capacitor should short, it would also blow the fuse, thus preventing damage to the transformer.

Another approach to limiting overvoltage is simply to put a big zener diode across the regulated output of the supply. The zener is rated at the maximum voltage you want to allow (for example, 15 volts) and should be designed to handle about as much current as the power supply is rated for.

If a heavy-duty lead-acid battery is floated across the power supply output in parallel with the load, it alone will limit overvoltage to reasonably safe values. If the regulator fails or a pass transistor shorts, the excess energy is absorbed by the battery and converted into heat, letting the voltage rise only a little. Prolonged operation in this mode, of course, will eventually damage or destroy the battery, but no major harm is done during short periods, allowing ample time to shut down the supply and the equipment connected to it.

metering

A power supply — especially one designed for heavy duty — is much more convenient if it is provided with meters to read both voltage and current. This can be done with ordinary 0-50 μA meters or even 0-1 mA meters, as follows.

Since 50 μA meters are available inexpensively from Radio Shack and other suppliers, and since they offer

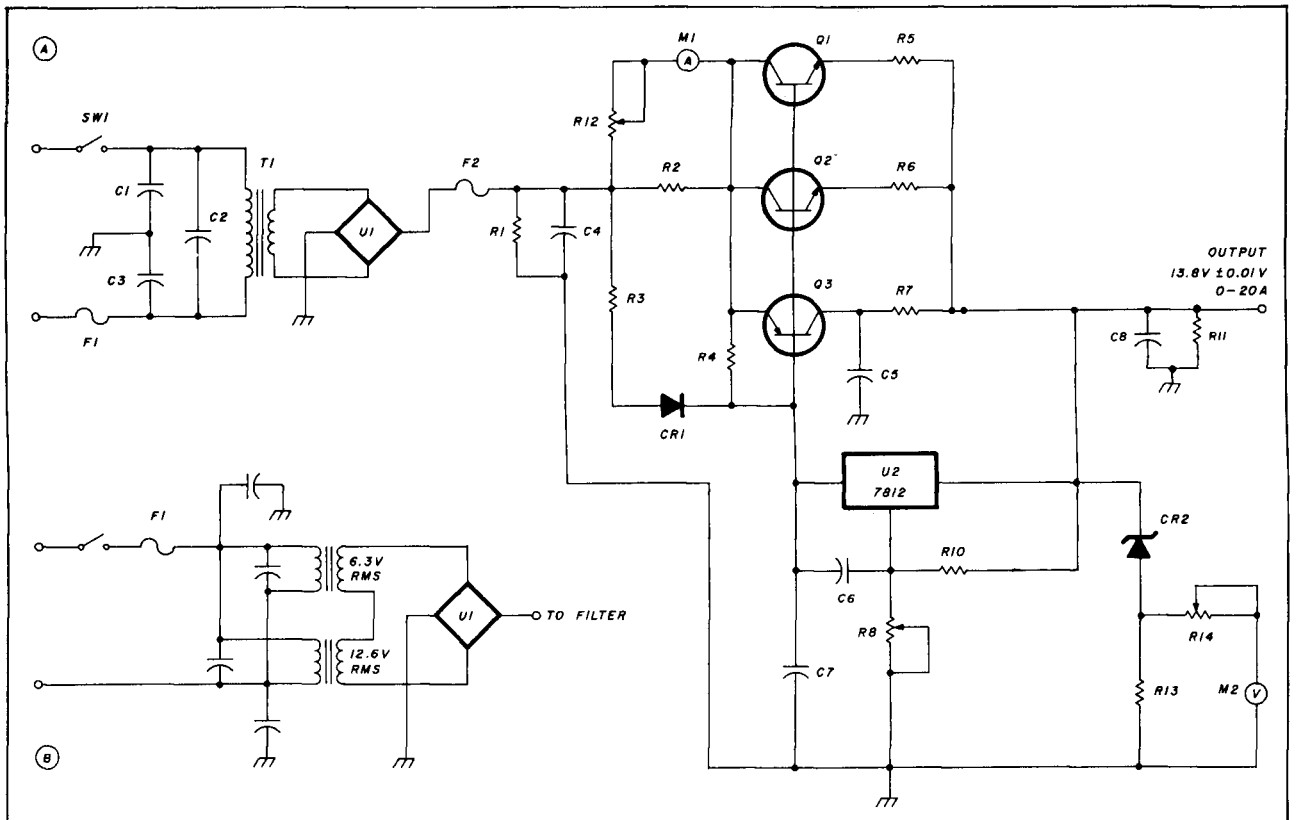


fig. 9. (A) Schematic of the power supply based on features discussed in the text. Circuit provides 13.8 volts at 20 amperes intermittent, 15 amperes continuous. Regulation is 0.01 volt; (B) Detail of T_1, using transformers in series.

a convenient scale, we'll use one to measure both voltage and current, as illustrated in **fig. 9**. Essentially, both circuits use the meter in series with a multiplying resistor to measure the voltage drop across a resistor. This avoids any need to calculate and wind super-accurate, super-low resistance shunts for the ammeter.

To measure voltage, the circuit provides an expanded scale that reads from 10 to 15 volts. CR2 is a 10.0 volt zener selected especially for accuracy. If it operates at any other voltage — even 0.1 volt more or less than 10 volts — the meter will be accurate only at the voltage at which it was calibrated. R13 is chosen to let the zener draw a modest amount of current; a few milliamps is plenty. The μA meter, in series with R14, then reads the voltage drop across R13 which will always be 10 volts less than the output voltage. To calibrate, put an accurate voltmeter across the power supply output and adjust R13 until the meters agree. Ten volts will now be 0 on the meter and 15 volts will read 50.

To read voltage, mentally insert a decimal point and add 10. Thus, 14 volts will read 40 on the scale, and 13.8 volts will read 38. (If you prefer, you can remove the plastic cover from the meter and renumber the dial.)

item	*description*
C1,C2,C3	*0.05 μF 600 volt*
C4	*40,000 μF 35 volt*
C5	*0.1 to 2.0 μF 50 kilohm (see text)*
C6	*0.1 μF 50 volt*
C7	*0.68 μF 50 volt (see text)*
C8	*0.25 μF 600 volt*
CR1	*2.5 amp diode 50 volt minimum*
CR2	*10.0 volt zener, 1.0 watt (see text)*
F1	*5 amp fuse*
F2	*25 amp cartridge fuse*
M1,M2	*0-50 μA DC*
Q1,Q2	*2N3055 or equivalent*
Q3	*ECG 129 or TIP 125 or similar PNP*
R1	*250 ohm 20 watt*
R2	*0.025 ohm 20 watt*
R3	*0.5 ohm 2 watt*
R4	*100 ohm 2 watt*
R5,R6	*0.1 ohm 5 watt*
R7	*75 ohm 1 watt*
R8	*1 kilohm linear*
R9	*omitted*
R10	*1.5 kilohm 1/2 watt*
R11	*150 ohm 5 watt*
R12	*20 kilohm circuit board potentiometer*
R13	*100 ohm 1/2 watt*
R14	*100 kilohm circuit board potentiometer*
SW1	*toggle switch SPST*
T1	*120 volt to 18-25 volt, 15-20 amp*
U1	*25 amp 50 volt rectifier bridge*
U2	*7812 regulator*

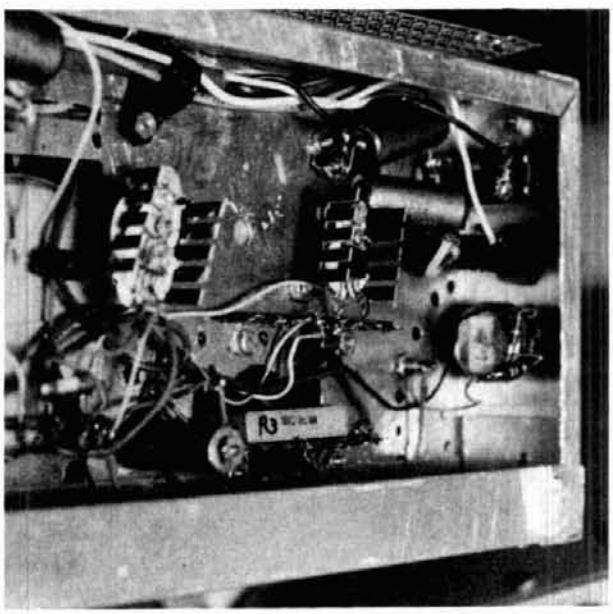
The ammeter, shown as M1 in **fig. 9**, is also rigged as a voltmeter, with R12 as a multiplier. The more current demanded from the supply, the larger the voltage drop across R2. The voltage is directly proportional to the current.

To calibrate, apply a resistor of known value across the power supply output and calculate the current it draws at the output voltage. A 2-ohm load resistor will draw 7 amperes at 14 volts (since I = E/R). A 10-ohm resistor will draw 1.4 amperes at 14 volts.

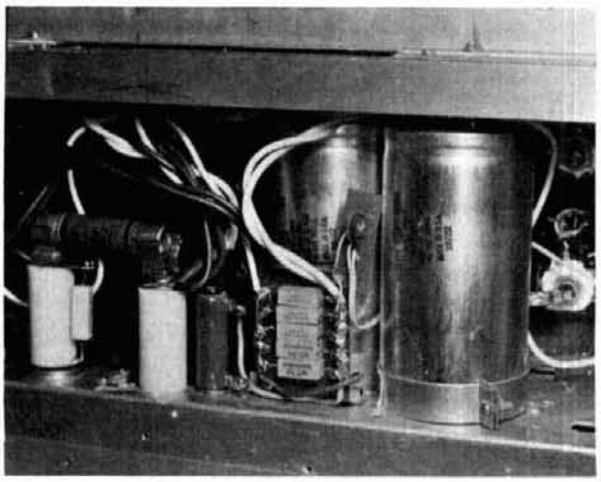
Before you calibrate, however, you must decide what scales you want to use. One scale should have the supply's rated output about mid-scale. Thus, our 20-ampere intermittent duty supply should have one scale that reads 0-40, or more conveniently, 0-50 amperes. Another range could be 0-5 amperes. In either case, the markings on the Radio Shack 0-50 μA meter are appropriate.

To calibrate for 0-50 amperes, use the 2-ohm load resistor and adjust R12 to make the meter read 7.0. The same meter can be used on two ranges by hooking up another potentiometer and switching the positive pole of M1 from R12 to the new potentiometer. The second pot could be set with the 10-ohm load resistor, adjusting it to give a reading of 1.4 (if the output voltage is 14).

The same meter can also be switched, of course, to read both current and voltage.



Bottom view of power supply chassis. Large can-like object at left is the 7 μF non-polar tuning capacitor of the ferroresonant core power transformer used in this supply. The two TO-200-case devices in the heat sinks are the 7812 regulator and drive transistor. The two power resistors (lower right) are in the input load-division network of the pass transistors and regulator chip. The two cylindrical objects at the top are tubular capacitors used to bypass AC lines.



Side view of power supply. At left is the 50-amp fuse mounted on two polystyrene pillars. A small bleeder resistor is mounted on the left-hand pillar. The five power resistors on the terminal board comprise the current-sensing resistor ahead of the power transistors. The calibration pot for the voltmeter is mounted on a small tab of circuit board atop the resistor terminal board. The filter capacitors are obvious. At right and behind the large capacitors is the rectifier heat sink with two 35-A 200-PIV diodes for the full-wave center-tap circuit.

the final product

The complete schematic of our finished example power supply is shown in **fig. 9**.

The capacitors in the transformer primary, C1, C2, and C3, are standard equipment and should be included in every power supply. They not only bypass RF that may be present on the power line but also tend to suppress voltage transient spikes coming down the power line by reducing their amplitude before they reach the transformer.

The low-voltage fuse, F2, is placed ahead of the regulator so that it will not degrade voltage regulation. The fuse has appreciable resistance; if it were placed in the output line, the voltage drop would be significant and would vary with the load current, thus degrading regulation.

R1 is simply a bleeder resistor designed to discharge the filter capacitor, C4, when the supply is turned off.

The power supply shown in the pictures is similar, but not identical, to the example supply described in this article. It is built around a 50-ampere saturable-core (constant voltage) transformer and uses six 2N3055 pass transistors in parallel. Four of them are mounted on the long heat sink on top of the supply. Two more are mounted on a smaller heat sink mounted at the back of the supply.

The voltage control pot, R8, is a 10-turn unit with a counter built into the knob, the knob farthest to the right on the front panel of the supply.

A small LED shines through a hole in the panel between the two meters to indicate that power is on.

It takes its voltage from the bridge, so that it won't be turned on by the battery system that normally floats across the output of the supply.

The sides and bottom, normally enclosed by cane-metal covers, have been left uncovered for photographic purposes. The project was built on a standard light-duty aluminum chassis reinforced with scrap sheet aluminum to support the 30-pound transformer. Pieces of 1-inch aluminum angle stock, mounted on the corners of the chassis, support angle-stock rails at the top. The rails, in turn, support the heat sink.

The 35-ampere, 200-volt rectifier diodes are mounted on a large heat sink that is enclosed by the cane-metal sides. The regulator chip and TIP-125 driver/inverter chip are mounted under the chassis on small heat sinks. All heat-sinked components are insulated with mica washers and silicone heat sink compound.

With the transformer and components shown, the supply can easily deliver 40 amperes or more continuously. The maximum capability of the supply has never been tested, but the pass transistors can easily handle 50 amperes continuously. The transformer was salvaged from a discarded computer terminal unit and the current-handling capacity was estimated from the core cross-sectional area the No. 4 wire used for the secondary center tap serving two secondary windings, each brought out on No. 10 wire. It is a ferro-resonant, saturable core unit with inherent voltage regulation properties providing better than 5 percent load regulation at the bridge output.*

The white pillar to the left of R2 is an insulating post supporting cables going to the B + output connector. The power resistor attached to the post is the bleeder resistor. The chassis-mounted power resistor between the post and R2 is R4. It doesn't need to be that big, but it was the only unit I had with the right resistance value.

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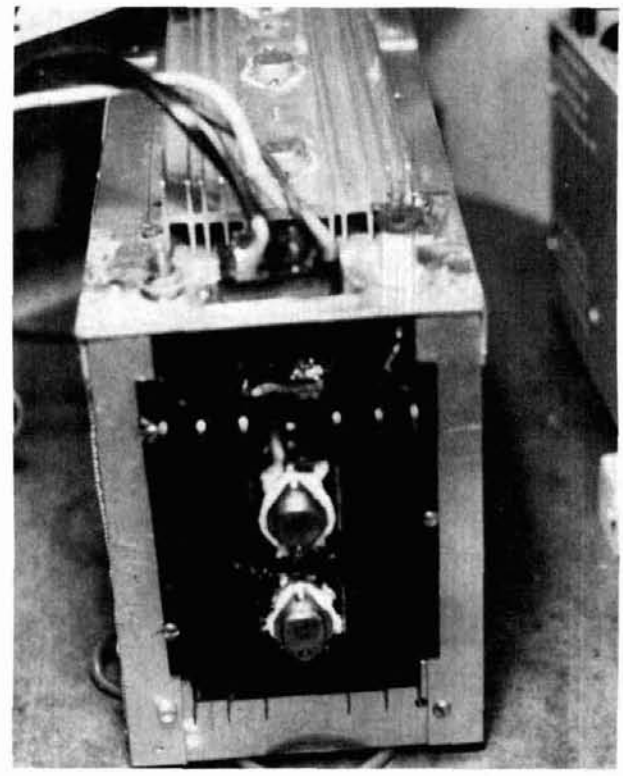
*The transformer I used is an uncommon and expensive type salvaged from a computer terminal. Suitable transformers of conventional design ranging from $45 to $65, depending on size and features selected, may be obtained from Avatar Magnetics, 1147 N. Emerson Street, Indianpolis, Indiana 46219. Avatar is operated by Ron Williams, W9JVF. Information sheets are free on request.



A rear view of power supply, with the two pass-transistor heat sinks in view. The output connector and cable appear at the top of the unit. The cable consists of two conductors, each made of two No. 10 stranded wires in parallel.

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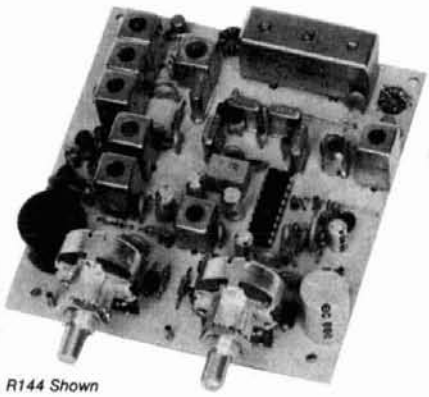

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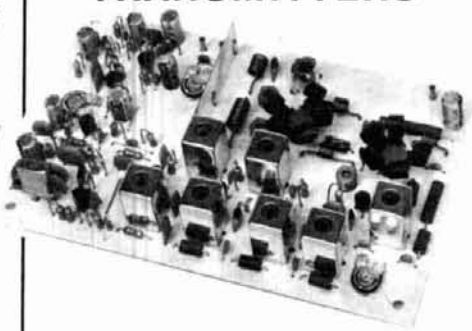

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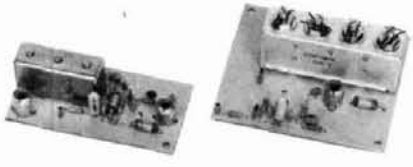

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	144-144.4	27-27.4
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	222-224	28-30
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	50-54	220-224
	144-146	50-52
	50-54	144-148
	144-146	28-30
For UHF,	28-30	432-434
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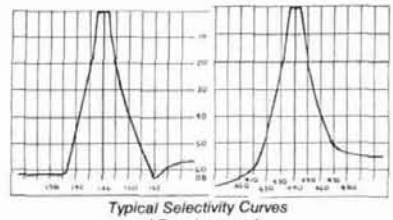

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It's easy to get going. You probably already have the radio, and the computer or terminal. You'll need to operate your computer in RS232C mode using "communications terminal" software that is free or cheap. We can usually furnish information on what to use for popular computers. The rest of the software is resident in the PKT-1 (you will need to buy a PKT-1). And you need a MIC connector to connect to the (furnished) radio cable you'll plug into your radio MIC jack. And "BRAAP," you're on the air with "Packet Racket."

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This article also appeared in the February, 1984 issue of *A5-Amateur Television Magazine*™, the official journal of the United States ATV Society (804 Jefferson Avenue, Lowden, Iowa 52255) — Ed.

fast-scan ATV power amplifier

Modification of 4CX250B design boosts power, improves image

After running QRP (6 watts) Fast-Scan Amateur TV for a year, I decided I wanted to build an amplifier for ATV that would give me a substantial amount of power as well as good quality video, color, and subcarrier sound. After talking with Ron Stefanskie, W9ZIH, who runs *really* high power (500 watts from a commercial broadcast tube — an 8938), I decided I couldn't afford this approach and probably wasn't technically competent enough to build it anyway. Bill Bryant, K9KKL, my mentor, made up my mind for me. After seeing his single 4CX250B run 70 video watts, I started looking for information and parts to build a two-tube 4CX250B (K2RIW design) amplifier. The hardest part was collecting the parts. It took a whole summer of hamfests and a winter of contacting friends to finally gather everything needed.

modifying the linear

After some research, I decided to build the basic K2RIW design. Since I had no plans to run it on SSB, and only on ATV, I built everything heavy duty to withstand continuous-duty video transmissions, and to grid-modulate the tubes with video. Because of the bandwidth restrictions of the grid circuit, the sync pulses, the 3.579 MHz colorburst, and the 4.5 MHz sound subcarrier signals are severely attenuated if you run the amplifier as a linear. But by driving the amplifier with an FM carrier, feeding your video and subcarrier audio via a video modulator into the control grids of the 4CX250B's, you are able to avoid the effects of the grid circuit. Now the only circuit left to affect the video is the plate line, and its bandwidth is wide enough to pass good color, sound, and excellent resolution if it's properly tuned.

Basically, I followed the original construction article for the amplifier with some minor changes.[1] I trimmed the plate stripline inductor, L1, to resonate at 439.250 instead of 432 MHz. The grid feed-through capacitor, originally 1000 pF, was changed to a value that will pass video; I used 60 pF. The screen grids must be video-bypassed with a 10 microfarad capacitor (450 volt rating) as well as RF bypassed with a 1000 pF feed-through. The grid metering cannot be utilized because of the video modulated negative bias voltage. Bypassing is very important for the grid compartment because of high RF fields and the inclusion of video.

Even though the original article called for SK-610 sockets, forget it! Use the SK-620s or SK-630s with the built-in screen-bypass ring. And while the original article called for beryllium copper for the flappers, I used silver plated brass. The plate line and plate load capacitors, as well as the grid line inductors are all silver plated, too.

ready-made modules simplify construction

I used the VM-2 grid modulator and FMA-5 subcarrier audio board available from P.C. Electronics* to modulate the grids. I found several things necessary for good results. Use short shielded leads between the subcarrier audio board and the modulator, and between the modulator and grid feed-through capacitor. All power supplies, modulator supply, grid bias and screen supply should be well regulated. The bias voltage should be adjustable so it can be set for best results. The carrier injection level from the subcarrier audio generator is important, because too high a level destroys the color, and too low a level will eliminate the audio.

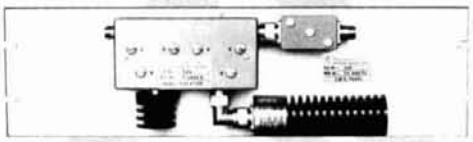
The frequency of the audio board should be within ±10 kHz of 4.500 MHz. A series trap consisting of a capacitor and inductor resonant at 4.5 MHz must be placed at the point where the video is fed into the modulator. This keeps the video line from loading down the 4.5 MHz signal.

Probably the most important part of this whole operation is the tuning of the amplifier for a good high resolution and good color with subcarrier audio signal. Tune to the high sideband side of the signal so as not to attenuate the sync pulses and 4.5 MHz audio signal.

*P.C. Electronics, 2522 Paxson Lane, Arcadia, California 91006.

By Dave Williams, WBØZJP, 5501 Holborn, St. Louis, Missouri 63121

R.F. Power Monitoring



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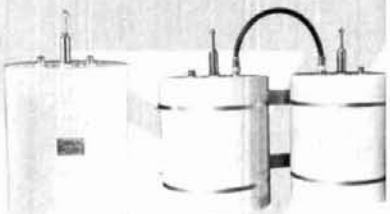
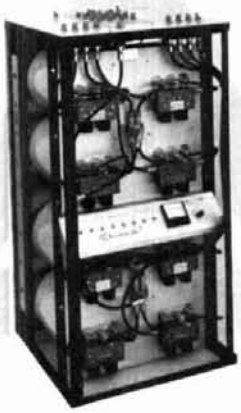


Bandpass, Pass-Reject and Notch Cavity Filters



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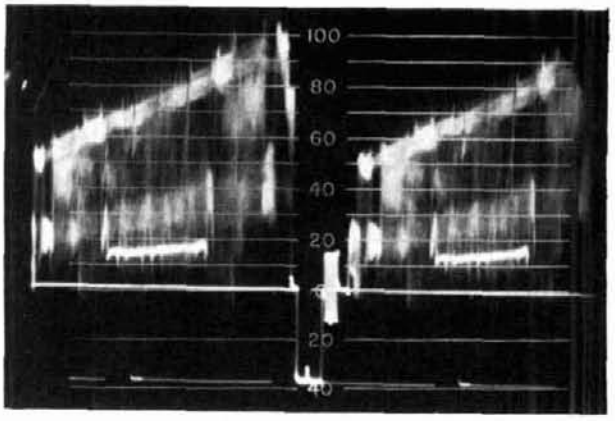
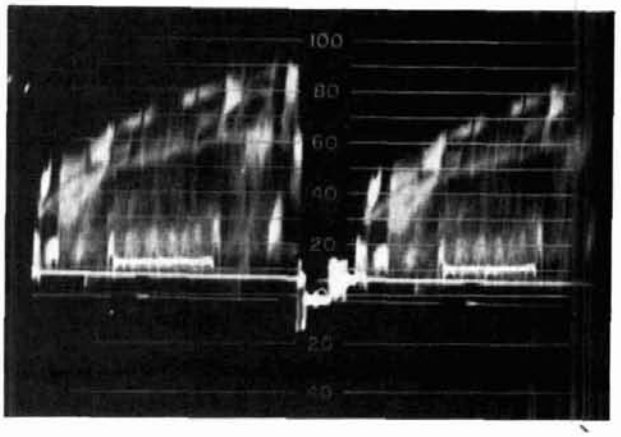
tune-up is easy

To tune the amplifier properly, I strongly recommend using an RF/video detector at the amplifier output. I use a DM-1 RF/video detector board (also available from P.C. Electronics) and use capacitive disc coupling in the plate compartment to sample the outgoing signal and feed it into my detector. This then goes into an RCA TO-1 waveform monitor, although any oscilloscope with a bandwidth of 5 MHz will work. You can observe your transmitted video waveform and the effect tuning the amplifier has on it.

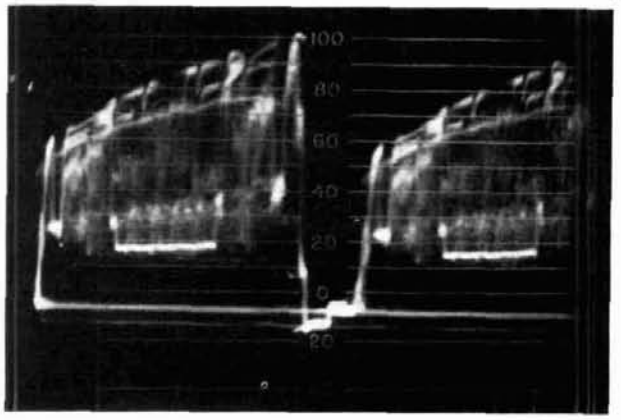
You cannot tune for maximum power out as in SSB. Instead, tune for as much power out as possible while still maintaining a good quality video waveform without clipping sync pulses, color-burst, and 4.5 MHz audio subcarrier signals. I drive my amplifier with an old T-44 Motorola FM transmitter strip with about 10 watts. That's not saying you couldn't build up a solid-state 439.250 MHz FM exciter or even drive it with one of the all mode or FM transceivers on the market that covers that frequency. With 10 watts of drive 1350V on the plates, and 400 milliamperes of current at −60



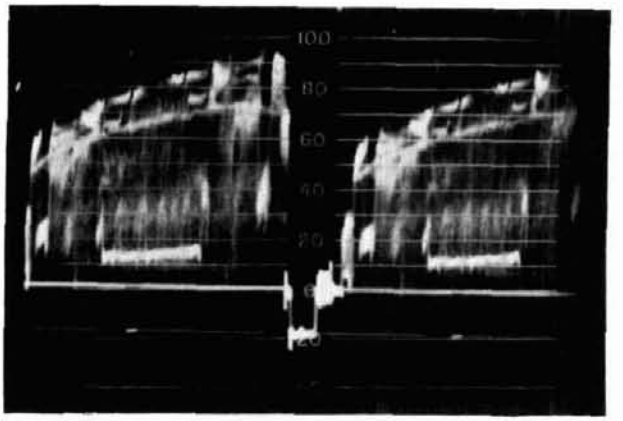
A correct video waveform showing the 0 line or blanking level, the sync pulse, color burst and video information from 0 to 100, 0 being reference black and 100 being reference white.



Shown here: the amplifier was tuned for maximum power out, but look at the sync pulse!



Believe it or not, this produced a picture. Shown here is what happens when the amplifier is tuned on the wrong sideband; notice that the sync pulse and color burst signals are gone. (The overall quality of this picture was poor.)



Sync compression is shown here from trying to tune the amplifier for that extra watt of power. What you think you gain in power you lose in the ability for your picture to lock up under weak signal condition.

Faceplate of the amplifier which is rack mounted with the power supply. Notice the "video in" connector (SO-239) and video level adjustment pot and "audio in" (1/4-inch phone plug) and level adjustment pot.

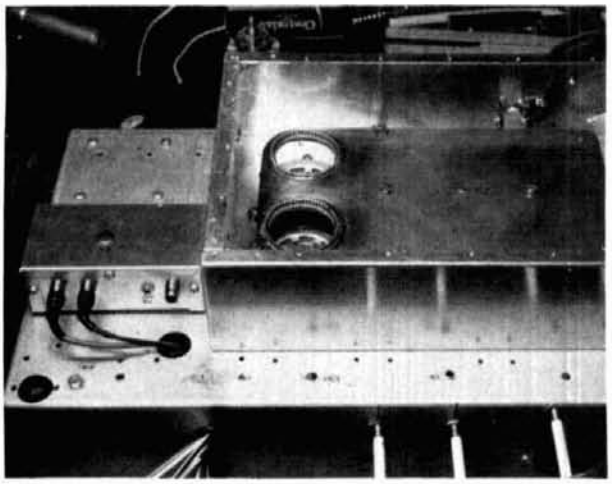
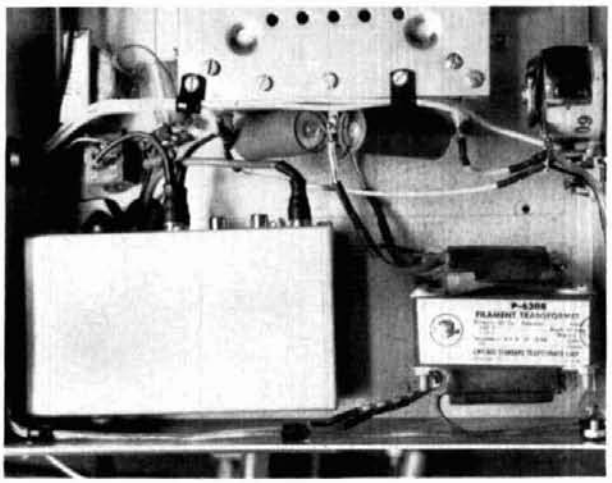


Plate line inductor and compartment, with audio subcarrier generator (left). The 4.5 MHz audio signal goes through the chassis via shielded cables to the modulator located underneath with the grid box.



This photo shows the grid modulator (top) in relation to the grid compartment. Notice 10 microfarad. 450 volt bypass capacitors on the grid box for the screen. Filament transformer is shown in the lower right; the modulator should be close to grid feed-through and shielded cables used.

volts of bias, I get 200 watts of acceptable quality color video and sound. For black and white operation only and without sound, I can push it to over 300 watts. Run properly, the hottest air temperature from the tubes is 115 degrees, and this is after one-hour of key down! So for those of you who have an existing RIW type amplifier or are thinking of building one to operate on 439.250 MHz Fast-Scan ATV, for a little extra effort and a few extra parts, you can be rewarded with high power, high-resolution FSATV pictures.

reference

1. Richard T. Knadle, Jr., K2RIW, "A Strip-Line Kilowatt Amplifier for 432 MHz," *QST*, April, 1972, pages 49-55; May, 1972, pages 59-62, 79.

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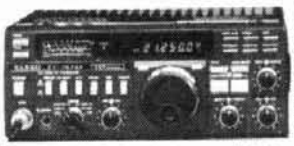

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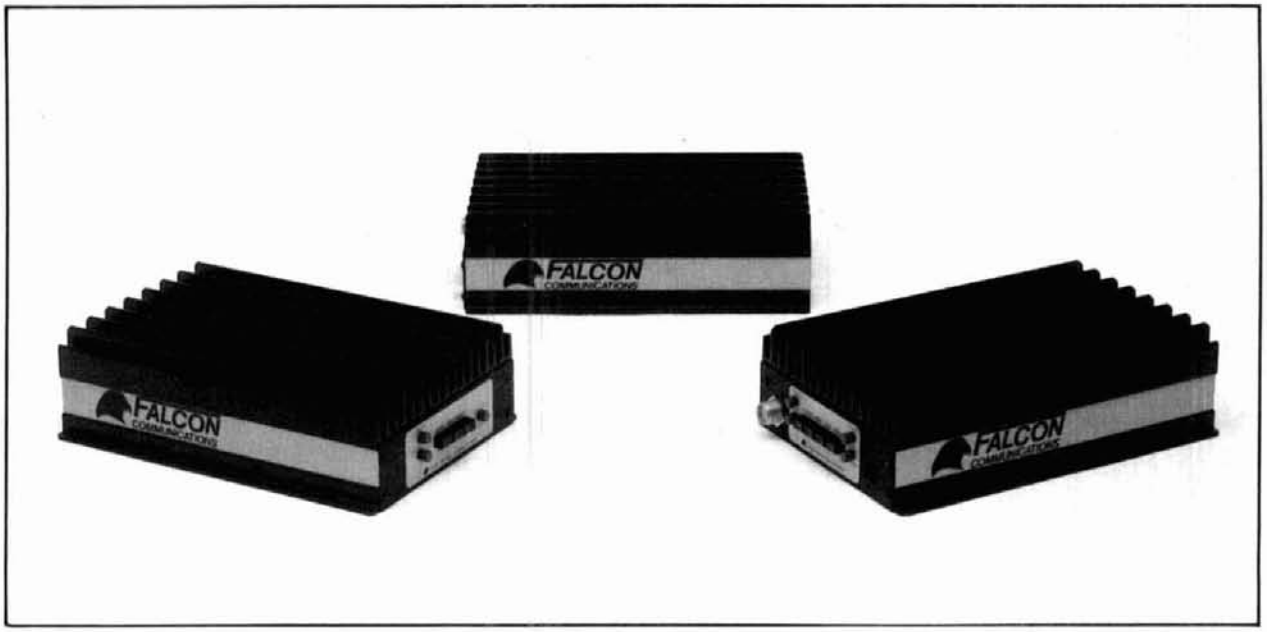

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predicting solar outages

Don't worry. We're not in imminent danger of losing the sun. The term "solar outage" merely describes the phenomenon in which radio reception suddenly deteriorates, with a decreasing signal-to-noise ratio. This article is addressed to Radio Amateurs experimenting with the reception of signals from the geosynchronous satellites operating in the 3.7-4.2 GHz region (not an Amateur band). — Ed.

A solar outage occurs when a particular satellite, as "seen" by the antenna of a receiving station on Earth, is directly in line with the sun. This phenomenon occurs only twice a year for only a short period of time, with the duration of the outage primarily determined by the size of the antenna and its elevation.

Used in conjunction with the information provided in **table 1**, the computer program provided in **fig. 1** allows the determination of the date of solar outages. Declination of the sun, a necessary input, can be found in any current almanac or calculated using **eq. 1**.

Alternatively, the following formula can be used to calculate the sun's declination.

$$Dec = ARCSIN\ (SIN_{El} \times SIN_{LAT} + COS_{El} \times COS_{AZ} \times COS_{LAT}) \quad (1)$$

where Dec = sun's declination (measured in degrees)
El = elevation angle (from the antenna to the satellite)
Lat = latitude of the receiving station (measured in degrees)
Az = azimuth or bearing from the antenna to the satellite (measured in degrees)

Use either method to determine the value of declination needed for insertion in the program listed in **fig. 1**.

During my first year of TVRO experimentation I built a parabolic dish faced on the inside with tinfoil. In my haste to put it into operation in time for Christmas, I postponed painting the foil until early spring, when the weather would be a little warmer. On February 26th, when I arrived home late in the afternoon, I noticed that part of the feedhorn was lying on the ground, looking as if it had been shot. Though the temperature was in the 30's, the focusing action of the dish produced temperatures *over 2000 degrees F (933 degrees C)*. Luckily the LNA was not damaged.

This shouldn't happen with today's dishes, although *I have seen a number of unpainted dishes in use.* Remember to be very careful with that huge solar mass; I've since learned to respect the sun.

The program shown in **fig. 1** is written for the Radio Shack TRS-80 color with extended BASIC. With minimal changes, the routine should work with most other personal computers as well. Remember that most computers work in radians rather than in degrees, so degree value must be divided by (180/pi). At the end of the program, multiply the value by 57.295 to obtain degrees.

provide these inputs:

EL — See any satellite tracker program. (One is available from the author. See details at end of article. — **Ed**)

AZ — See above

LAT — Check with local government agencies or purchase 7.5 minute topographic maps from local stationary or book stores.

Example. The elevation of the antenna is 31 degrees and azimuth is 197 degrees. The antenna latitude is

By Vern Epp, VE7ABK, 705 6th Street, Nelson, B.C., Canada

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70 INPUT"ELEVATION IN DEGREES IS";EL
80 INPUT"AZIMUTH OF SATELLITE DISH IN    DEGREES IS";AZ
90 PI=3.1416
100 DR=180/PI
110 DEC=(SIN(EL/DR)*SIN(LAT/DR)+ COS(EL/DR)*COS(AZ/DR)*COS(LAT/D
R))
120 X=ATN(DEC/SQR(DEC*DEC+1))*57.295
130 PRINT"THE TRUE DEC IS ";:PRINT USING"###.###";X;:PRINT" DEGR
EES"
140 PRINT@462,"WANT ANOTHER?"
150 A$=INKEY$:IF A$=""THEN 150
160 IF A$="Y" THEN 10
```

fig. 1. TRS-80 color computer program listing helps determine the sun's declination angle throughout the year.

table 1. General-purpose almanacs provide declination values in minutes and degrees; for use in program, these must be converted to decimals.

Feb		15	-02.25	09	+07.47	Sept		27	-01.52
19	-11.37	16	-01.85	10	+07.85	01	+08.38	28	-01.92
20	-11.02	17	-01.45	11	+08.22	02	+08.02	29	-02.30
21	-10.65	18	-01.07	12	+08.58	03	+07.65	30	-02.68
22	-10.30	19	-00.77	13	+08.95	04	+07.28		
23	-09.93	20	-00.27	14	+09.32	05	+06.92	Oct	
24	-09.57	21	+00.13	15	+09.67	06	+06.55	01	-03.08
25	-09.18	22	+00.52	16	+10.03	07	+06.17	02	-03.47
26	-08.82	23	+00.92	17	+10.38	08	+05.80	03	-03.85
27	-08.45	24	+01.32	18	+10.73	09	+05.42	04	-04.23
28	-08.07	25	+01.70	19	+11.08	10	+05.05	05	-04.63
		26	+02.10	20	+11.42	11	+04.67	06	-05.02
March		27	+02.48			12	+04.28	07	-05.40
01	-07.68	28	+02.88			13	+03.90	08	-05.78
02	-07.30	29	+03.27	Aug		14	+03.52	09	-06.15
03	-06.92	30	+03.67	20	+12.53	15	+03.13	10	-06.53
04	-06.53	31	+04.05	21	+12.22	16	+02.75	11	-06.92
05	-06.15			22	+11.88	17	+02.37	12	-07.30
06	-05.77	April		23	+11.53	18	+01.98	13	-07.67
07	-05.38	01	+04.43	24	+11.20	19	+01.58	14	-08.05
08	-05.00	02	+04.82	25	+10.85	20	+01.20	15	-08.42
09	-04.60	03	+05.20	26	+10.52	21	+00.82	16	-08.78
10	-04.22	04	+05.58	27	+10.17	22	+00.42	17	-09.15
11	-03.82	05	+05.97	28	+09.82	23	+00.03	18	-09.52
12	-03.43	06	+06.35	29	+09.45	24	-00.35	19	-09.88
13	-03.03	07	+06.73	30	+09.10	25	-00.75	20	-10.23
14	-02.63	08	+07.10	31	+08.75	26	-01.13	21	-10.60

table 2. Number of solar outage days and duration.

antenna diameter (feet)	8	10	12	16	20
outage	16	14	12	10	8
outage during these days (minutes)	30	24	20	15	12

Note: To determine the beginning of the outage period find the *middle* day (using **fig. 1**) then use this table to locate, under your antenna size, the **total** span of outage days and divide by 2.

49 degrees. These values, when entered, provide a declination of −8.37. The almanac indicates these dates as February 27 and October 15th. From the outage days chart (**table 2**) we find that by using a 10-foot dish, we have solar degradation for ±7 days for a period of approximately 24 minutes.

The outage chart shown in **table 2** is designed for 4 GHz operation and provides the total number of days in which some solar degradation can be expected to occur. The time, expressed in minutes, represents the approximate duration of the anticipated outage.

Information provided in the appendix can be used to determine the exact time of day which the outage will occur.

reference

1. Dennis Mitchell, K8UR, "Receiving Signals from Space," *ham radio*, November, 1984, page 37.

appendix

time of the day calculations

Step 1

$$LHA = ARC\,COS\left[\frac{SIN_{EL} - (SIN_{LAT} \times SIN_{DEC})}{COS_{LAT} \times COS_{DEC}}\right]$$

Step 2

$$GMT \cong \frac{(LHA + longitude)}{15} - 12$$

LHA Local angle hour is measurement of the sun's current position (measurement in degrees)
EL Elevation of dish on earth
LAT Latitude in degree of earth station
DEC Declination of the sun measured in degrees
GMT Greenwich Mean Time
LONGITUDE Earth station in degrees

Note: GMT must be converted to local area time

Vern Epp's computer program, "Satellite Tracker, ($34.95) includes routines such as geo-sat location, dish design and efficiency evaluation, polar Dish Design LNA conversions, and C/N calculation. Also available is a program for predicting solar outages, ($11.95) that calculates outage times using built-in charts. A number of other useful routines are included. Both programs are written for TRS-80C extended BASIC computer. For details, contact the author at the address given on page 75.

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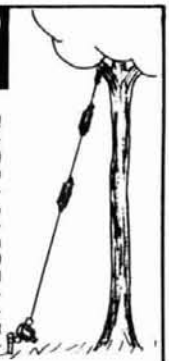

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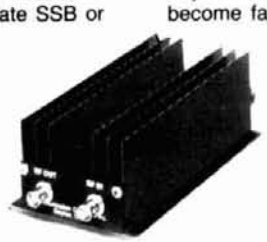

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More Details? CHECK—OFF Page 160

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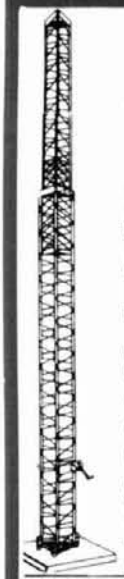

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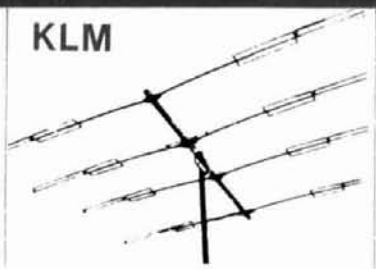
HBX48	48 ft	10 sq ft	303	$399
HBX56	56 ft	10 sq ft	385	$489
HDBX40	40 ft	18 sq ft	281	$379
HDBX48	48 ft	18 sq ft	363	$469

*Your Total Delivered Price Anywhere in Continental 48 States. Antenna Load Based on 70 MPH Wind.

KLM



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KT34XA List $633.95 SALE $499.00

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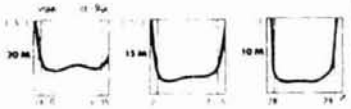

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- RG8X—95% Bare Copper Shield
- Low Loss
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Cable Type	Imped.	10MHz	30MHz	150MHz	450MHz
RG-213/U	50	.6	.9	2.3	5.2
RG8X	52	.8	1.2	3.5	6.8
RG-58/U	52	1.4	1.9	6.0	12.5
½" Alum	50	.3	.5	1.2	2.2
½" Heliax	50	.2	.4	.9	1.6
⅞" Heliax	50	.1	.2	.5	.9

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Lowest Loss for VHF/UHF!

½" Alum. w/poly Jacket	$.79/ft
½" LDF4-50 Andrew Heliax ™	$1.69/ft
⅞" LDF5-50 Andrew Heliax ™	$3.99/ft

select connectors below.

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Cable Type	UHF FML	UHF MALE	N FML	N MALE
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½" Heliax ™	$22	$22	$22	$22
⅞" Heliax ™	$49	$49	$49	$49

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Silver PL259 $1.25 UG23D N Female $2.95
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450 Ohm H.D. Line	$.16/ft
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H.D. End Insulators	$2/ea
Van Gorden 1:1 Balun	$11
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4BTV 40-10 mtr Vert $89 5BTV 80-10 mtr Vert $109
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10-3CD	$ 95	10-4CD	$109
15-3CD	$119	15-4CD	$129
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40-2CD	$289	D40	$149

VHF/UHF BEAMS

A50-5	$ 79	617B	$199
214B	$ 79	3219	$ 95
220B	$ 95	424B	$ 79

OSCAR/TWIST ANTENNAS

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A147-20T	$ 63	416TB	$ 59
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TH3JRS 3-el Triband Beam	$185
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205BAS 5-el 20-mtr Beam	$349
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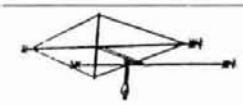
TA40KR 40 mtr Kit for TA33	$119



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- Wind Area - 1.5 sq ft
- Boom - 54 in. long
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KLM

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KT34XA 6-el Broad Band Triband Beam	$499
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40m-2 2-el 40-mtr Beam	$309
40m-3 3-el 40-mtr Beam	$459
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2m-13LBA 13-el 2-mtr Beam	$79
2m-14C 14-el 2-mtr Satellite Antenna	$89
2m-16LBX NEW-16-el 2-mtr Beam	$99
2m-22C NEW-22-el 2-mtr Satellite Antenna	$119
432-30LBX NEW-30-el-432 MHz Antenna	$99
435-18C 435 MHz Satellite Antenna W/CS-2	$119
432-16LB 16-el 432 MHz Beam	$69

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Alliance HD73 (10.7 sq ft rating)	$99
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Telex HAM 4 (15 sq ft rating)	$219
Telex Tailtwister (20 sq ft rating)	$269
Telex HDR300 Heavy Duty (25 sq ft rating)	$519
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Standard 8 cond cable $.19/ft (vinyl jacket 2-#18 & 6-#22 ga)
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Heavy Duty Tripods include mtg hdw-UPS Shippable

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10 ft Stack Sections

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Model	Height	Ant Load*	Price
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FK2558	58 ft	13.3 sq ft	$ 899
FK2568	68 ft	11.7 sq ft	$ 959
FK4544	44 ft	34.8 sq ft	$1159
FK4554	54 ft	29.1 sq ft	$1259
FK4564	64 ft	28.4 sq ft	$1359
25G Foldover Double Guy Kit			$199
45G Foldover Double Guy Kit			$229

*Above antenna loads for 70 MPH winds and Guys at Hinge & Apex.

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3/16" EHS Guywire (3990 lb rating)	$.15/ft
1/4" EHS Guywire (6000 lb rating)	$.18/ft
5/32" 7 × 7 Aircraft Cable (2700 lb rating)	$.15/ft
3/16" CCM Cable Clamp (3/16" or 5/32" Cable)	$.45
1/4" CCM Cable Clamp (1/4" Cable)	$.55
1/4" TH Thimble (fits all sizes)	$.45
3/8EE (3/8" Eye & Eye Turnbuckle)	$6.95
3/8"EJ (3/8" Eye & Jaw Turnbuckle)	$7.95
1/2"EE (1/2" Eye & Eye Turnbuckle)	$9.95
1/2"EJ (1/2" Eye & Jaw Turnbuckle)	$10.95
3/16" Preformed Guy Grip	$2.49
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6" Diam - 4 ft Long Earth Screw Anchor	$14.95
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GALVANIZED STEEL MASTS

Heavy Duty Steel Masts 2 in OD - Galvanized Finish

Length	5 FT	10 FT	15 FT	20 FT
.12 in Wall	$25	$49	$59	$79
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B1016
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Model	Band	Pre-amp	Input	Output	DC Pwr	Sale Price
A1015	6M	Yes	10W	150W	20A	$249
B23	2M	No	2W	30W	5A	$ 79
B215	2M	Yes	2W	150W	22A	$259
B108	2M	Yes	10W	80W	10A	$159
B1016	2M	Yes	10W	160W	20A	$249
B3016	2M	Yes	30W	160W	17A	$199
C22	220	No	2W	20W	5A	$ 79
C106	220	Yes	10W	60W	10A	$179
C1012	220	Yes	10W	120W	20A	$259
D24	440	No	2W	40W	8A	$179
D1010N	440	No	10W	100W	20A	$289

RC-1 Remote Control for Mirage Amplifiers $24
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Model	Cont. Amps	ICS Amps	Price
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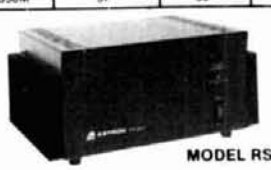
RS7A	5	7	49
RS12A	9	12	69
RS20A	16	20	89
RS20M	16	20	109
RS35A	25	35	135
RS35M	25	35	149
RS50A	37	50	199
RS50M	37	50	229



MODEL RS-50A

CP-1 COMPUTER PATCH
List $239.95 SALE $189.95!

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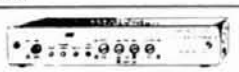
All AEA Keyers, Antennas & Accessories In Stock!



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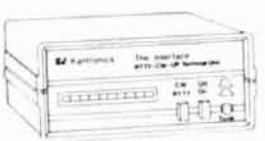
901 300W Tuner	$59.95
941C 300 W Tuner	$89.95
989 Deluxe 2KW	$299.95

Kantronics



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Model 64 Amtor Soft	89	Hamtext Model-64	99
Apple Hamsoft	29	Atari Hamsoft	49
		TRS-80C Hamsoft	59

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ham radio TECHNIQUES

Bill Orr W6SAI

It may be too early in the year to start working on your antenna, but it's not too soon to start thinking about interesting antenna designs! Here's a good one for you.

the "K3ZVH Special" for 40 through 10 meters

This antenna design came to me via Jack Walker, VE4DS, who got the information from J.A. Hutcheson, K3ZVH, who has a summer home in Selkirk, Manitoba, where Jack lives. The antenna covers 40, 30, 20, 15, and 10 meters, and provides a low value of SWR on each band (**fig. 1**). It is a "fat," center-fed, broadband dipole. Old Timers may find a tear in their eyes as it brings back memories of the old cage antenna, so popular in the early 1920's. This design, however, works on a different principle.

The overall length of the antenna is 85 feet (25.9 meters) and cage diameter is 2 feet (0.61 meter). The antenna is fed at the center with a 300-ohm, two-wire line. VE4DS uses open-wire "ladder" line and K3ZVH uses good-quality 300-ohm transmitting ribbon line. Line length is not critical. A 4-to-1 balun provides a good match to a 50-ohm coaxial line.

building the antenna

The antenna is built of No. 16 enamel wire; the hoops are made of aluminum TV ground wire bent into a circle. The ends of the hoops are joined by a short piece of copper tubing, which is used as a compression sleeve. The wires are attached to the hoops by small pieces of copper wire twisted around the joint.

The assembly can be quite unwieldy unless it is strung out in a line under tension, preferably slung between two low supports. (It would be logical to string one wire of the cages between the supports and then build the rest of the cage around that wire.) The wires are spaced equidistant around the loops, and the tie-wires are wrapped with electrical tape after the assembly is finished. Because it doesn't seem to matter whether electrical contact is made between the loops and the antenna wires, no effort was made to make such a connection.

For lowest SWR (usually required with a solid-state transmitter), a simple antenna matching unit is placed at the transmitter. If the transmitter can work into an SWR as high as 2:1, no tuner is required.

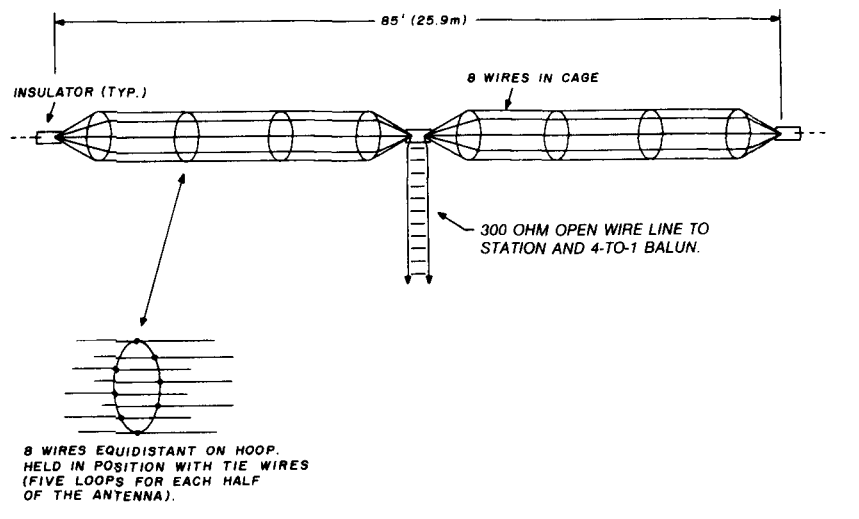
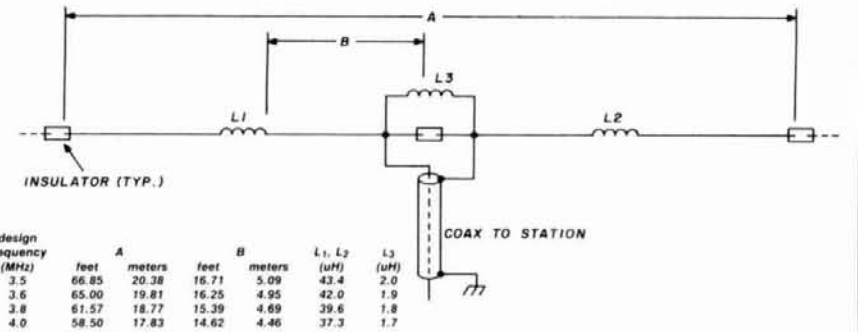


fig. 1. The K3ZVH "fat dipole" for 40 through 10 meters.

some thoughts on the K3ZVH antenna

It would be interesting to run an SWR plot of this antenna over the spectrum from 5 MHz to 30 MHz. Because of the "fat" design, I would think that impedance excursions from a mean value would be modest and the antenna might qualify for operation over the whole frequency range. Many military "broadband" antennas are built in this fashion. If any reader of



design frequency (MHz)	A feet	A meters	B feet	B meters	L_1, L_2 (uH)	L_3 (uH)
3.5	66.85	20.38	16.71	5.09	43.4	2.0
3.6	65.00	19.81	16.25	4.95	42.0	1.9
3.8	61.57	18.77	15.39	4.69	39.6	1.8
4.0	58.50	17.83	14.62	4.46	37.3	1.7

antenna wire size: 14 AWG
L_1, L_2, L_3 diameter = 2 inches (5 cm)
(all coils are close wound)

3.5 L_1, L_2 = 36.5 turns, L_3 = 4.8 turns
3.6 L_1, L_2 = 35.0 turns, L_3 = 4.7 turns
3.8 L_1, L_2 = 34.0 turns, L_3 = 4.6 turns
4.0 L_1, L_2 = 32.5 turns, L_3 = 4.4 turns

fig. 2. Compact dipole design for 80 meters.

table 1. Characteristics and operating parameters of the EIMAC 3CX1200A7.

plate voltage	3600 volts
cathode voltage	3.4 volts
zero-signal plate current	220 mA
single tone plate current	700 mA
two-tone plate current	500 mA
single-tone grid current	215 mA
two-tone grid current	130 mA
useful power output (CW or PEP)	1750 watts
3rd-order IMD products	−34 dB
single tone drive power	108 watts
filament voltage	7.5 VAC
filament current	21 amperes
input capacitance	20 pF
output capacitance	0.2 pF
cooling: 30 CFM at 0.5 inch/water (anode to base) (cooling air must be supplied to base)	

Note: Zener bias derived from four G.E. 1N5062 diodes in series, forward biased, or Motorola 1N4549.

this column would care to make a frequency-sweep of this design, I'd be happy to hear about the results.

the 80-meter compact dipole

In my February column I described a half-size 160-meter dipole for those unfortunate hams who do not live on 200 acres atop a high hill. The same technique can be used to make a compact 80-meter dipole that will give a good account of itself (**fig. 2**). This dipole is only about 65 feet (19.8 meters) long and has a bandwidth of about 50 kHz where the VSWR is less than 2:1. Antenna length is a compromise between efficiency and bandwidth and the same truths that apply to the 160-meter antenna shown last month apply to this antenna: a loaded antenna can be just about any length, but the tradeoffs must be accepted. This design is a good compromise, and I recommend it.

Three coils are needed — two loading coils to be placed in the flattop and an impedance matching coil placed across the feedpoint. A balun is not required and the antenna is fed directly from a 50-ohm coax line.

adjusting the antenna

Once the antenna has been built, it is erected in place, but at a low elevation so that a dip-meter can be coupled to the matching coil, L3. The end sections are trimmed equally until resonance is established for low-end (3.5-3.7 MHz) or high-end (3.8-4 MHz) operation. The feedline is removed for this adjustment.

When antenna resonance is established, the antenna is pulled up to its final position and SWR measurements are made across the frequency band of operation. Matching coil L3 is adjusted, a quarter-turn at a time, for the lowest SWR on the feedline at the frequency of antenna resonance. Refer to the discussion of the 160-meter antenna in my February column for details of the loading and matching coil construction and installation.

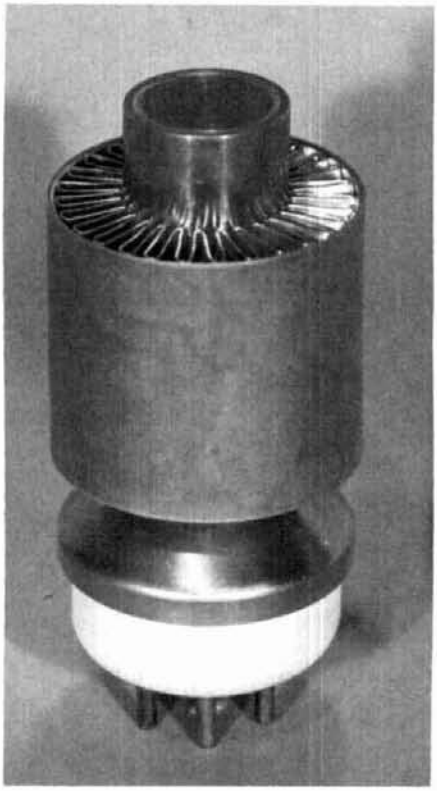


fig. 3. The new EIMAC 3CX1200A7 high-μ power triode.

the new EIMAC 3CX1200A7 power triode

In recent months Varian EIMAC has released data on a new tube of interest to Radio Amateurs — the 3CX1200A7 (**fig. 3**). For Old Timers, I can say it is the "Son of 3-1000Z." For newcomers, it is a 1200-watt dissipation,

high-μ power triode intended for cathode driven, linear amplifier service. The tube is very compact, being only 6 inches (15.3 cm) high and 2-5/8 inches (6.7 cm) in diameter. The tube is air-cooled and is rated for full input to 110 MHz.

The characteristics and typical operating parameters of the 3CX1200A7 are listed in **table 1**.

Using the 3CX1200A7

The 3CX1200A7 is well-suited for linear amplifier service because it provides maximum FCC-rated power output at a drive level compatible with today's modern solid-state exciter.

A representative circuit for the 3CX1200A7 in linear service is shown in **fig. 4**. This is a cathode-driven, grounded-grid configuration. A π-L network output circuit is chosen for maximum harmonic attenuation and a π-network input circuit is used to provide a good match between the exciter and the amplifier (**tables 2** and **3**). Current metering is done in the return leads to the power supply so no high voltage appears on the meter movements.

Standby and operating bias voltages are provided in the grid-filament return circuit. Operating bias is set by a Zener diode to approximately +3.4 volts. The resting plate current is determined by the value of zener bias. With no bias, at a plate potential of about 3600 volts, resting plate current is nearly 250 mA, so a small value of bias lowers the current and reduces plate dissipation. For standby, additional cathode bias is added in the form of a 10k resistor to reduce the current to a very low value. The resistor is shorted out by contacts on the VOX relay.

A 50-ohm wirewound resistor from the negative side of the plate supply to ground makes certain that the negative terminal does not rise to the value of the plate voltage if the positive side of the supply is accidentally shorted to ground.

Two reverse-connected diodes are shunted across the safety resistor to limit any transient surges under a shorted condition that might cause wiring insulation breakdown or meter damage. A resistor across the zener diode provides a constant load for it and prevents cathode voltage from soaring if the zener safety fuse should open.

A 10-ohm, 50-watt resistor is placed in series with the B-plus lead to the plate RF choke. The resistor serves as a low-Q VHF choke to suppress harmonic currents in the power lead and also protects the tube and associated circuitry in case of a flash-over in the tube or plate circuit. The considerable amount of energy stored in the power supply filter capacitor is instantaneously "dumped" into the amplifier in the unlikely event of a flash-over, and much of this destructive energy is dissipated in the resistor.

the step-start circuit

The resistance of the thoriated tungsten filament of the 3CX1200A7, when cold, is about one-tenth its value at operating temperature. As a result,

Parts list, 3CX1200A7 amplifier.

item	description
C1,C2	*see table 2*
C3,C4	*see table 3*
CR1	*10 volt, 50 watt zener diode*
J1,J2	*coaxial chassis connector (SO-239 or equivalent)*
J3	*high voltage connector*
M	*0-10 volt iron-vane type AC meter (RMS responding)*
M1	*0-1 ampere DC*
M2	*0-500 mA DC*
PC	*three 100-ohm, 2-watt resistors in parallel shunted by 3 turns No. 14 AWG, 0.5-inch diameter, 0.75-inch long. Coil may be wound around one resistor.*
RFC1	*50 μH. 14 bifilar turns No. 10 AWG enamelled wire wound on ferrite core 5 inches long, 0.5-inch diameter (Indiana General CF503 or equivalent)*
RFC2	*100 μH, 1 ampere DC; 112 turns No. 26 AWG space wound on 1-inch ceramic or teflon form 6 inches long. Series-resonant at 24.5 MHz with terminals shorted (B&W 800A, or equivalent)*
T1	*7.5 volts at 21 amperes, tapped primary*
TD	*time delay relay (3 seconds) Amperite 115-NO3*

Note: All capacitors other than C1 through C4 are 0.01 μF, 600 volt. Capacitors are mica type.

table 2. Cathode circuit component values with an R_C of 60 ohms.

band	C1 (pF)	C2 (pF)	L1 (μH)
160	3300	3100	3.53
80	1700	1670	1.90
40	900	840	0.96
20	440	417	0.47
15	300	275	0.32
10	220	205	0.23

table 3. Plate circuit component values with an R_L of 2750 ohms.

band	C3 (pF)	C4 (pF)	L2 (μH)	L3 (μH)
160	330	1550	33.0	11.2
80	165	775	16.5	5.6
40	80	385	8.2	2.7
20	40	190	4.1	1.4
15	27	130	2.7	0.9
10	20	100	2.0	0.7

Note: Data on plate circuit design can be found in the 22nd edition of the *Radio Handbook*, available from Ham Radio Bookstore, Greenville, NH 03048.

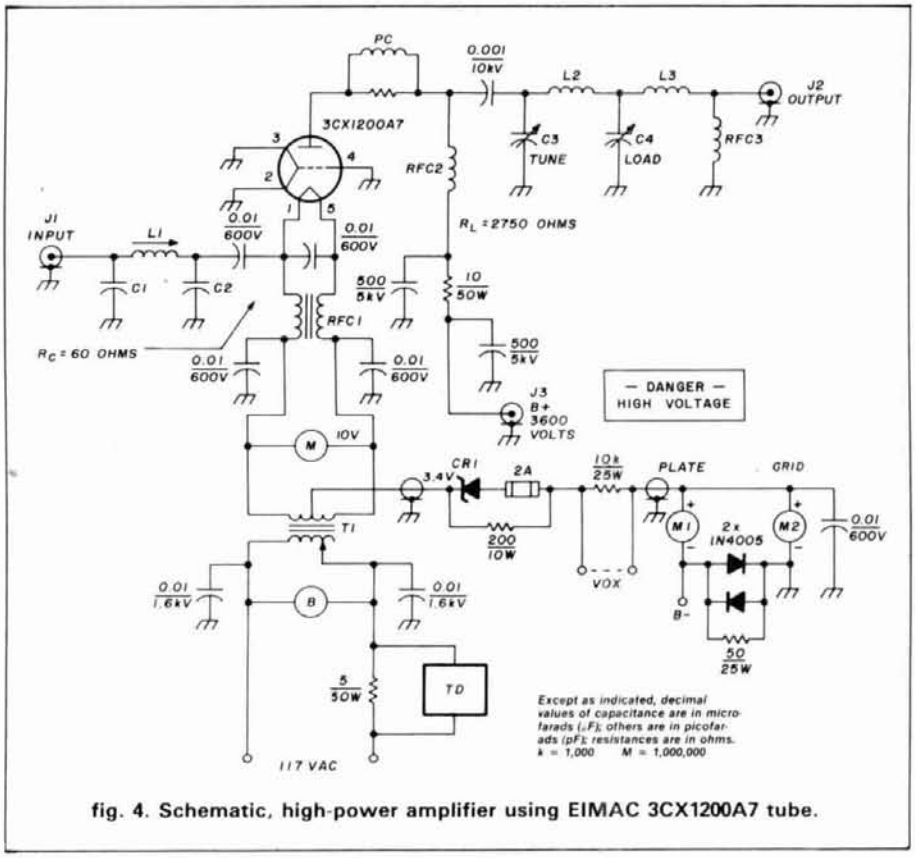


fig. 4. Schematic, high-power amplifier using EIMAC 3CX1200A7 tube.

a filament inrush current as high as 210 amperes may occur for a fraction of a second. It is good commercial practice to limit filament inrush current as this powerful surge can warp or otherwise strain the filament structure of the tube. This design incorporates a simple inrush time delay (TD) protection circuit that applies reduced voltage to the tube filament for a short period, then allows application of full voltage when the filament has had a chance to warm up a bit. Total time delay is only a matter of seconds, and is a wise precaution because the circuitry costs but a fraction of a replacement tube!

safety factors

It's a good idea to use a filament transformer having a primary winding tapped for various line voltages. A filament voltmeter can provide the operator with a close check on voltage, which should be held to ±5 percent of the nominal value of 7.5 volts.

Complete, detailed information on the design and construction of high-power amplifiers of this type can be found in the 22nd edition of the *Radio Handbook*, available from Ham Radio's Bookstore, Greenville, New Hampshire 03048.

radio tube closeout

Edlie Electronics is closing out their surplus tube department. Their 1985 catalog lists over 550 types of receiving tubes at two for a dollar, ten for $3.95, and 50 for $15. All have been tested, but are sold "as is" with no guarantee. Most are boxed.

For details, contact Edlie Electronics, 2700 Hempstead Turnpike, Levittown, New York 11756 (516-735-3330).

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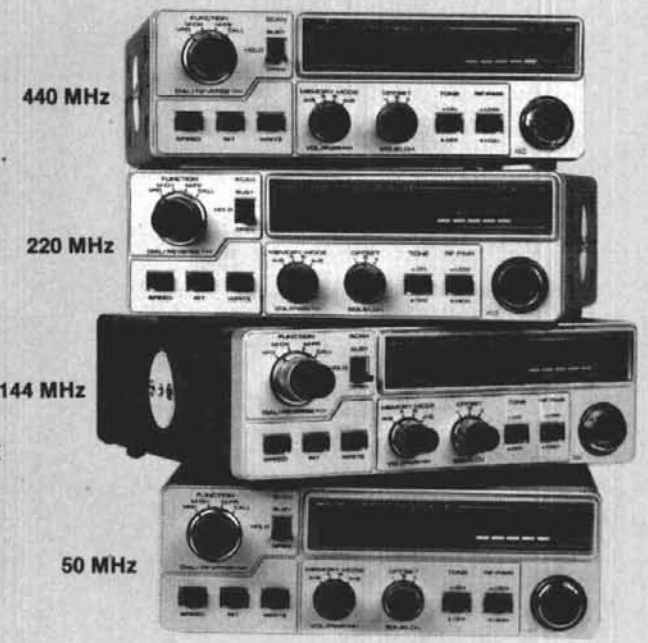

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get on 6 meters — the inexpensive way

Converting the CRT-1/CPRC-26

The CRT-1/CPRC-26 radio set shown in **fig. 1** is an ideal unit for low cost, multichannel 6-meter FM operation. A Canadian-designed and manufactured six-channel, crystal-controlled receiver-transmitter, it covers the 47.0 to 55.4 MHz frequency range with a power output of 300 milliwatts. The receiver's sensitivity is 2 microvolts; its deviation is approximately 15 kHz. All that's necessary to make the CRT-1/CPRC-26 operational is a power supply and the Canadian version of the U.S. Military H-33/PT Handset. You can even modify the basic unit described in this article to include speech limiting, squelch circuitry, and provisions for loudspeaker operation.

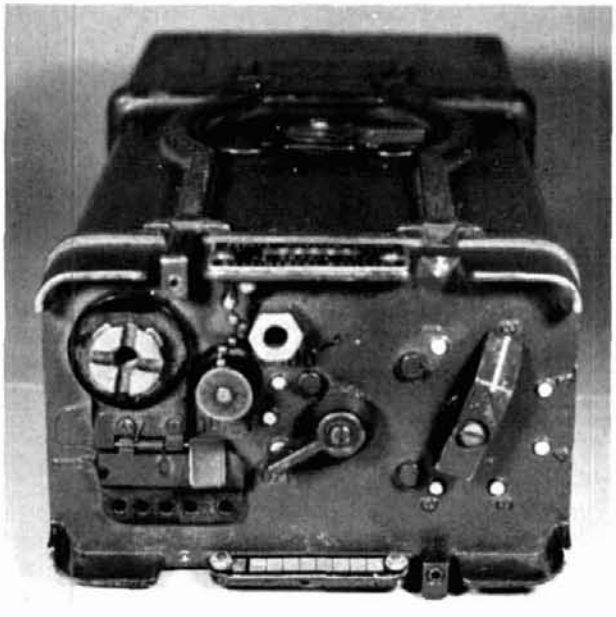

fig. 1. The CRT-1/CPRC-26 radio set represents an easy way of "getting on" 6 meters.

theory of operation

Figure 2 shows a block diagram of the radio set. Incoming signals are amplified in the RF amplifier, V7, and applied to the mixer, V8, along with the output of the crystal oscillator, V4, to produce an IF of 4.3 MHz. The crystal frequency equals the frequency of operation minus 4.3 MHz. The IF signal is then amplified through four identical IF amplifier stages and fed to the limiter, V10. The signal is then routed through the audio discriminator to the audio amplifier, V6, and to the earphone element of the handset via the output transformer, T1.

Audio input from the microphone element of the handset is applied through the microphone transformer, T2, to the modulator, V3. The amplified audio is next fed to the master oscillator, V2, via the master oscillator coil. The audio input varies the frequency of the master oscillator to produce direct FM. The output from the master oscillator, V2, is then applied to the power amplifier, V1, and routed to the antenna via the output tuning network.

Because the master oscillator is essentially a VFO, some method is needed to ensure that the transmitter frequency tracks the receiver frequency. Therefore, the output from the mixer, V8, is fed to the AFC amplifier, V5, during transmit, through the AFC discriminator to the master oscillator, V2, via voltage dividers R5 and R6. In effect, output from the crystal oscillator, V4, provides transmitter frequency control.

power supply

The power supply for the radio set consists of an inverter for high and low B + and a simple + 1.4-volt

By Mark Starin, KB1KJ, 457 Varney Street, Manchester, New Hampshire 03102

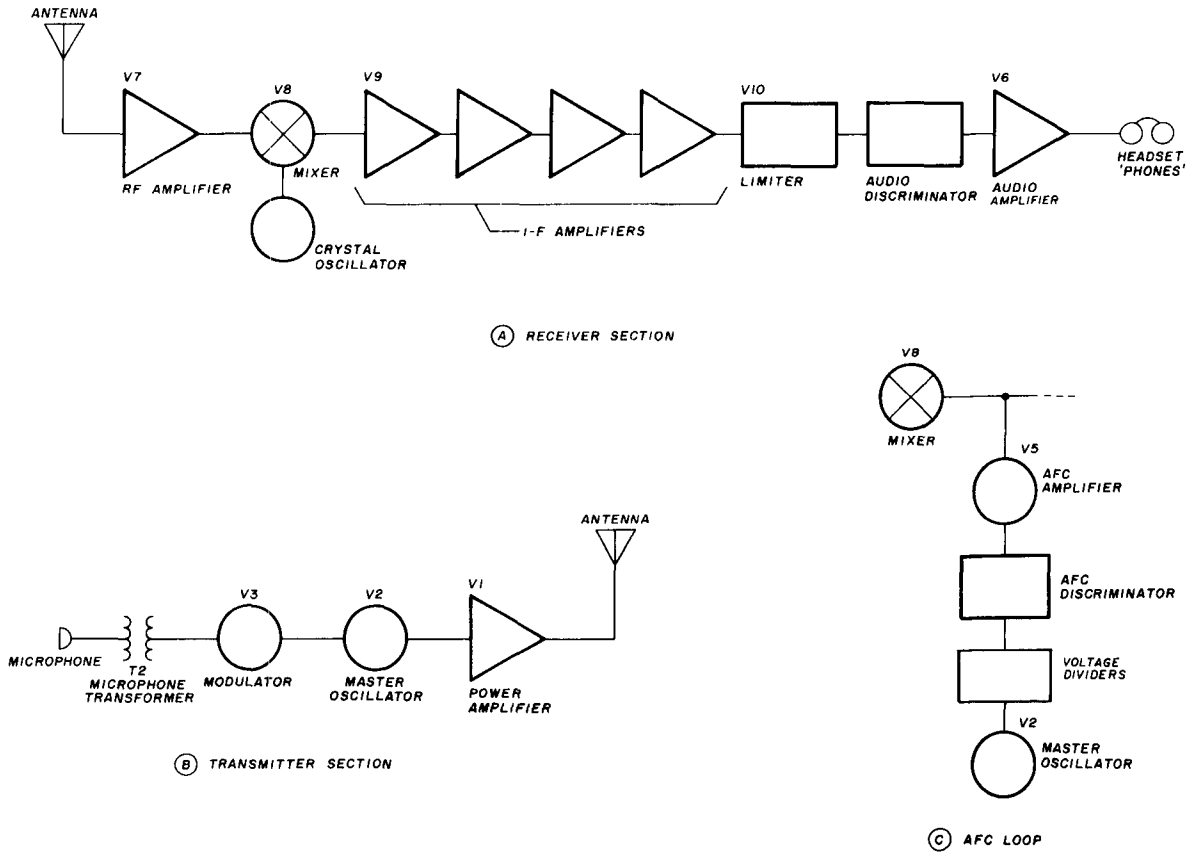

fig. 2. The CRT-1/CPRC-26 radio set block diagram (*A*) receiver section, (*B*) transmitter section, and (*C*) AFC loop.

filament regulator board. Bias is supplied by two +1.5-volt N cells connected in series and mounted on the filament regulator board. Both the inverter and the filament regulator board fit inside the battery box, which attaches to the rear of the radio set. A schematic of the filament regulator circuit is shown in **fig. 3.**

The inverter can be either bought or built. A surplus transistorized inverter module, P/N 522-1091-004, is available from Fair Radio Sales Company, Inc., (see **fig. 4**). The only disadvantage of this choice is that unless the inverter is modified, a +24-volt DC power source will be needed. This might prove to be a problem for anyone operating from a typical automobile. A schematic diagram for this circuit is shown in **fig. 5.** With +13.8 volts power applied to U1, the input regulator circuit, R1, is adjusted until the output voltage present at C3 is +140 volts maximum. This occurs when Q1 and Q2 are biased into oscillation by R3 and R4, which produces high-voltage AC at the secondary of transformer T1. This AC voltage is rectified by CR1, filtered by C3, and applied to the input of the U2 output regulator circuit. Note that the LM317 is capable of high-voltage regulation provided the input voltage does not exceed the output voltage

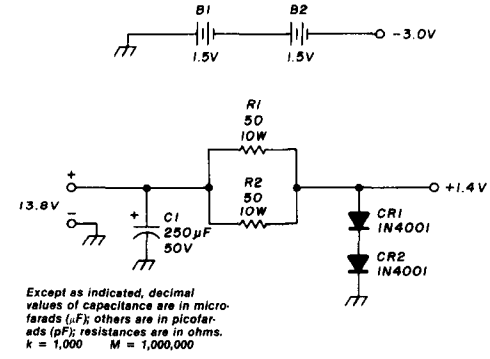

fig. 3. The filament regulator circuit uses a pair of 1N4001s to meet the 1.4 volt bias requirements.

by more than 40 volts. Therefore, I recommend that the input regulator be set to produce approximately 130 volts at the input of U2 (approximately +5 volts to the transistors). CR2 is a 40-volt zener diode that protects U2 if the input regulator circuit fails. Note that a simple voltage divider, consisting of R6 and R7, provides approximately +45 volts for the receiver and transmitter.

The + 1.4 volt filament regulator board consists of a series dropping resistor (two 50-ohm, 10-watt resistors in parallel), two 1N4001 diodes shunted to ground, and a filter capacitor. Although there are alternatives that will provide + 1.4 volts for the filaments, this circuit is especially simple.

The two N cells are another way to provide needed voltage — in this case, the bias voltage for the receiver audio amplifier. The N cells are mounted inside a standard 9-volt battery holder and secured to the battery holder with nylon ties. The battery holder is then mounted on the filament regulator board. Transistors Q1 and Q2 are mounted on the top of the battery box. Their placement is not critical; almost any convenient location on the battery box will probably work satisfactorily. The transformer is mounted inside the battery box on either the left or right side. The filament regulator board is also mounted inside the battery box on the side opposite the transformer. Connections from the power supply to the radio set are made with hookup wire wrapped around and soldered to the pins on the rear panel of the radio set. Heat-shrink tubing is then placed over these connections. In addition, a power cable was fabricated using a Radio Shack two-pin plug and matching jack (P/N 274-201 and 274-202), 12-gauge wire, and battery clips (Radio Shack P/N 270-344). **Figure 6** shows the power supply mounted in the battery box with the power cable attached. The dimensions of the filament regulator board are 1 inch

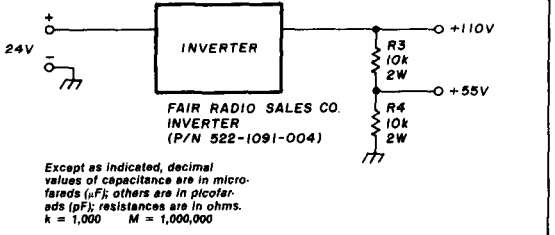

fig. 4. The inverter module, available from Fair Radio Sales, requires a +24 volt source of power.

table 1. Alignment procedure.

VTVM	channel	adjust	indication
2-volt scale, − DC position	1-6	C3-C8 C29-C34	maximum −1 volt
(Insert the probe into pin 3 of the test socket.)			
10-volt scale, + DC position (Insert probe into pin 4 of test socket. Press PTT (push-to-talk) switch on handset.)	1-6	C19-C24	zero indication between positive and negative peaks

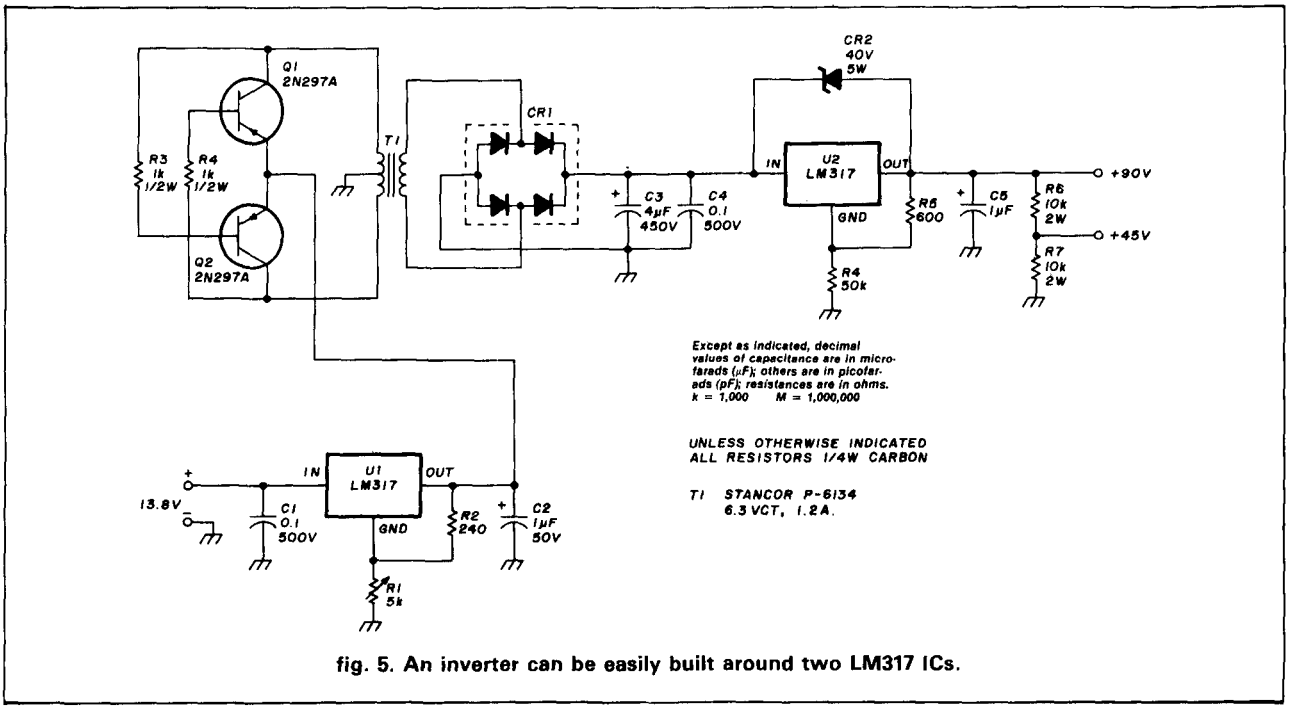

fig. 5. An inverter can be easily built around two LM317 ICs.

fig. 6. The complete radio set, shown with power supply and cable, measures 3 × 4.75 × 10.34 inches (7.62 × 12.07 × 26.26 cm).

(25.4 mm) by 2 inches (50.8 mm). The set's power requirements are as follows:

receiver:	+1.5 volts, 550 mA;
	+45 volts, 12 mA;
	+90 volts, 30 mA;
	−3 volts bias
transmitter:	+1.5 volts, 850 mA;
	+45 volts, 8 mA;
	+90 volts, 30 mA.

alignment

The alignment procedure for the radio set is easy and does not require elaborate test equipment. A VTVM and a 5/32-inch color TV tuning wand are necessary.

First remove the battery box from the rear of the radio set. Then remove the cover from the receiver-transmitter chassis. Apply +90, +45, +1.5, and −3.0 volts to the radio set. (Don't forget to connect a dummy load to the antenna connector on the front panel.) Install the appropriate crystals for the desired operating frequencies. Set the OFF/QUIET/LOUD switch to either the QUIET or LOUD position. **Figure 7** shows the radio set adjustment locations. **Figure 8** shows the major component locations. **Table 1** identifies the controls and proper indications to be observed during the alignment procedure.

obtaining materials

The primary source of the CRT-1/CPRC-26 Radio Set is Fair Radio Sales Co., 1016 East Eureka, Box 1105, Lima, Ohio 45802-1105. Their 1984 catalog price for the radio set — described as "used" — is $12.95. (The "used" radio set we bought appeared to be in

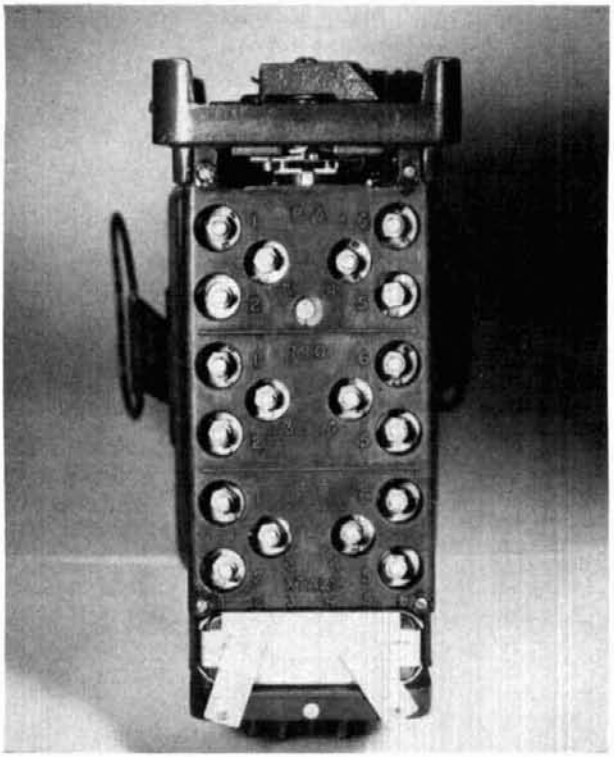

fig. 7. Alignment proceeds smoothly with easy access to the adjustable components.

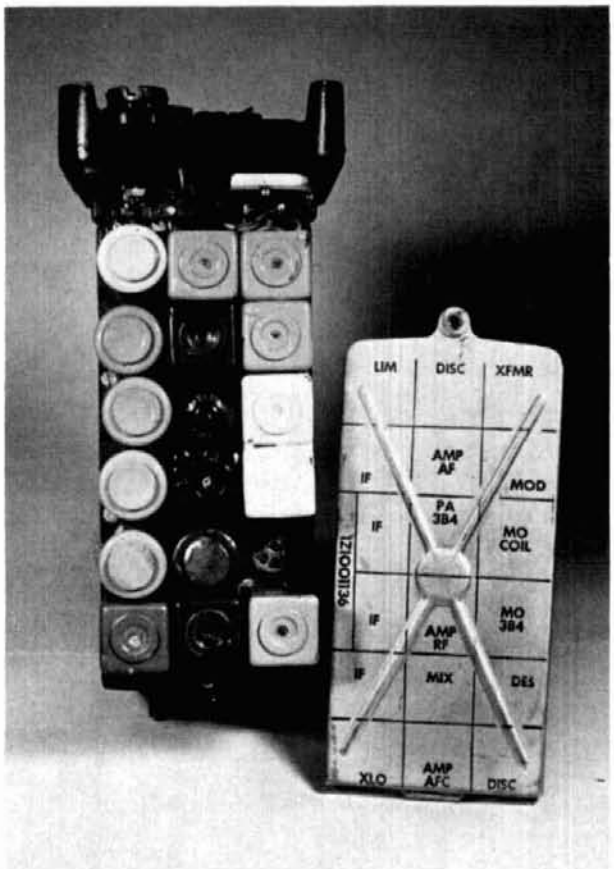

fig. 8. Exposed view of radio set with cover removed shows the location of the major components.

table 2. Spare module color codes and availability.

module name	color	availability (1984)
RF amplifier	black	no
mixer	brown	no
IF amplifier	orange	yes
limiter	yellow	no
audio discriminator	light green	no
audio amplifier	dark green	yes
crystal oscillator	red	yes*
AFC amplifier	dark blue	no
AFC discriminator	light green	no
mo coil	white	no
modulator	grey	yes
transformers	light blue	no

*"RF oscillator" is stamped on the module housing.

like-new condition.) The handset is also available at $8.95 and the schematic at $1.50. Fair Radio also sells spare modules at $1.50 each or 10 for $10 (you mix and match them). The inverter module is available from Fair Radio Sales for $9.95. **Table 2** shows the color codes for the various spare modules and whether they were available from Fair Radio in 1984.

Crystals for the radio set are normally CR-52A/U types that are not currently sold by Fair Radio. We were fortunate to obtain a complete CK-6/PRC-6 quartz crystal unit set for an AN/PRC-6 that saved us the expense of buying individual crystals. (This crystal pack occasionally shows up at flea markets.) However, third overtone crystals (Type EX, available from International Crystal Manufacturing) should also work, although we haven't tried them.

operation

After installing the power supply, connect +13.8 volts to the battery box rear connection, an antenna to the front panel mounted BNC connector, and the handset to the audio connector on the front panel. Set the OFF/QUIET/LOUD switch to either QUIET or LOUD. (Note that there is no deviation or microphone gain control on the radio set.) Because most of your contacts will probably be with stations operating narrowband equipment, back away from the microphone element on the handset when transmitting; this will help to minimize over-deviation.

Any antenna — from a quarter-wave whip to a multi-element Yagi or quad — can be used with this radio set. Although the 300 milliwatt output is definitely in the QRP category, a decent base station or mobile antenna will provide this little rig with a reasonable line-of-sight range.

acknowledgement

The author wishes to express his appreciation to Hal Weinstein, K3HW, Rich Royer, W1HZN, and Gene Balinski, WA1UXA, for their contributions to this article.

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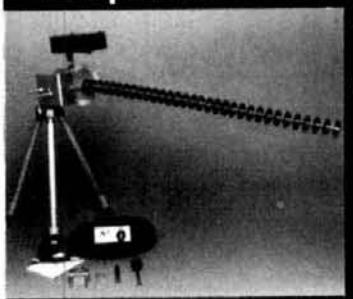

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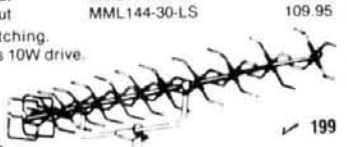

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Rhombics aren't for everyone. Not many Amateurs have sufficient space on their small city or suburban lots to accommodate the generous dimensions of this useful, efficient antenna. Mine measures 277 feet on each leg, and requires an area that measures 525 by 250 feet. Yet for those who have adequate land, rhombics can offer unusually high performance: the three wavelengths on my leg rhombic, for example, puts an *outstanding* signal into Europe on 30 meters, and when the 18 and 24 MHz bands are open, this antenna is all set to go.

In the mid-1930's, when the rhombic antenna was relatively new, ARRL experimenters[1] found it to be useful for long-distance radio communications. League personnel strung hundreds of feet of wire, in an enormous diamond configuration, through the Connecticut woods with astonishing results: signals from as far away as Australia were clearly heard.

As a young man, I duplicated the League's efforts behind my home in New Jersey. After climbing many trees, stringing springy lengths of No. 12 copperweld wire among and through their innumerable branches, I succeeded in constructing a rhombic antenna terminated in a 100-watt carborundum resistor and fed with a 600-ohm open-wire line. It was not until retirement that I was able to build other rhombics; this article, a result of these later experiments, describes the design of a rhombic that operates on the 160 through 10 meter bands and offers controlled vertical radiation in the 40 through 10 meter bands. This feature allows mechanical tuning to the best operating configuration for any band. (Fixed rhombics are best for one frequency and perform well over a 2 to 1 frequency range only.)

Because this rhombic is terminated in its characteristic impedance, it is nonresonant; its input impedance is essentially flat over its entire operating range. In steady use since the 1983 Radiosport contest — when I heard on 15 meters, such reports as "You're the only U.S. station coming through at this time," and "Your signal is overriding all other U.S. stations by 10 to 15 dB" — it has performed admirably and presented no maintenance or durability problems.

how does a rhombic work?

To begin, let's consider the rhombic's horizontal radiation plane, realizing that a rhombic is simply four long-wire antennas arranged in the shape of a rhombus or "diamond." By terminating the rhombic in its characteristic impedance (with a noninductive resistance), a unidirectional lobing pattern is obtained in the direction of the terminated end; (see **fig. 1**). The

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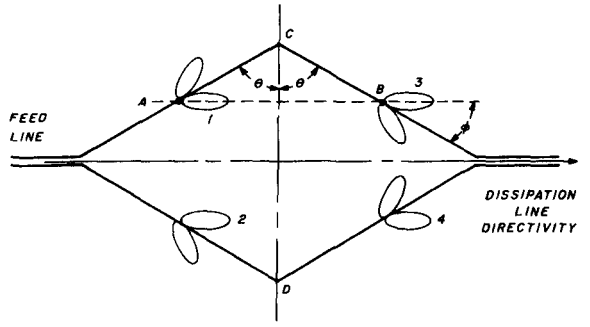

fig. 1. Unidirectional lobing pattern of a rhombic antenna is generated by terminating it in its characteristic impedance through a dissipation line. Lobes 1, 2, 3, and 4 combine their energy when θ, the tilt angle, is equal to 90 degrees minus ϕ.

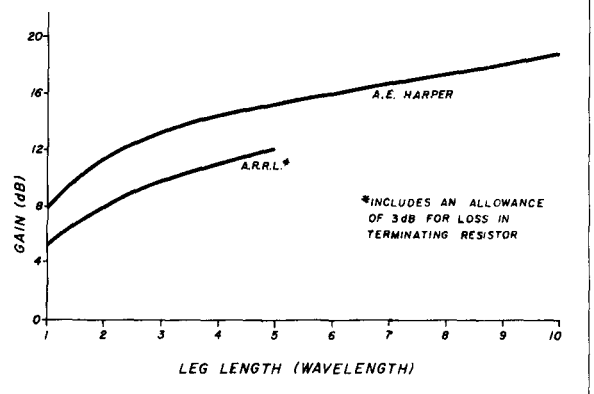

fig. 2. Free space gain of a rhombic antenna over a half-wave dipole for zero wave angle.

tilt angle, θ, shown in the figure, must be adjusted to equal 90 degrees minus the angle ϕ, between the main forward power lobe and the individual leg, which is determined by the antenna length. This ensures that maximum directivity is on a line bisecting the rhombic as indicated.

To obtain the correct phasing of the lobes for maximum radiation in the desired direction, the straight-line distance, AB, between the center of the legs, must be one-half wavelength less than the distance ACB. This follows from the fact that lobe 1 is 180 degrees out of phase with lobe 3. By making the distance between these lobes one-half wavelength (180 degrees) less, lobe 1 will arrive at point B in the correct phase to add to the field of lobe 3, and thus increase the intensity of radiation in the desired direction. A similar action takes place between lobes 2 and 4 on the other side of the rhombic. All other lobes combine to produce a cancellation of radiated energy in the line of the minor axis, CD. Correct termination of the antenna with approximately 800 ohms nonreactive resistance produces an almost infinite front-to-back ratio.

The issue of rhombic gain is a controversial one. **Figure 2** shows gain curves from two sources: *The ARRL Antenna Book*,[2] and *Rhombic Antenna Design*, by A. E. Harper.[3] Both curves are free-space directivity gains of a nonresonant rhombic over that of a dipole and are for *zero vertical angle of radiation*. E. Bruce, the major developer of the rhombic, shows some actual experimental data in his August, 1931, article in the *Proceedings of the Institute of Radio Engineers*.[4] His data shows that in comparison with a halfwave vertical antenna, his three wavelengths on a leg rhombic had a gain of 21 dB 10 percent of the time, to 7 dB 100 percent of the time, and 16 dB 50 percent of the time. Put another way, the rhombic was always 7 dB better than the halfwave vertical, and 10 percent of the time it was 21 dB better. That 21 dB relates to a power ratio of about 130; that is, a 1 kW output transmitter would have an effective radiated power of 130 kW with respect to a dipole — but only 10 percent of the time.

In a detailed article in the January, 1935, *Proceedings of the IRE*,[5] Bruce described experimental data showing that three and one-quarter wavelengths on a leg rhombic had 14 dB gain over a halfwave horizontal dipole at the same height. A Yagi producing 14 dB gain would require 12 elements — a rather large antenna; of course it would be capable of rotation over 360 degrees.

design

For optimum performance, a rhombic antenna should be designed for one frequency or a very small band of frequencies, the pattern for which is best suited to the propagation conditions of the radio circuit. Usually about all that a designer attempts to compute about this system is the characteristics of the main lobe. The enormous labor of computation quickly discourages analysis of a rhombic's complete radiation characteristics. Charts have been provided to assist in suitable designs as shown in the *ARRL Antenna Book*, or Laport's *Radio Antenna Engineering*, figure 3.81.[6] By careful design (and acceptance of less than optimum performance) a rhombic antenna may be made to operate over an almost 3 to 1 frequency range. This means that a fixed rhombic could operate from 3 to 9 MHz, or from 7 to 21 MHz, or over any similar frequency range. It will be shown later that a Controlled Vertical Radiation (CVR) rhombic can operate well from its lowest design frequency to as high as practical before beamwidth becomes too narrow for normal use.

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quencies and desired vertical angle of radiation, it is necessary to have a method for observing quickly the effects of varying any single parameter in relation to all the others. These parameters are the antenna height above ground, the length of the legs, and the included angle between the legs, called the tilt angle (see **fig. 3**).

The length and tilt angle (**fig. 3A**) are actual dimensions of the antenna proper and affect the free-space pattern. The height of the antenna, however, affects the directional characteristics only through what is called "ground reflection." In **fig. 3B**, part of the radiated power goes directly from the antenna at the vertical angle of radiation, delta. The rest of the radiated power is directed toward the ground at the same angle. If the ground is assumed a perfect reflector, the wave that is directed toward the ground will be reflected, undiminished in strength in the same direction as the original directly radiated wave. If the ground reflected wave arrives at a distant point (your QTH, for example) in phase with the direct (sky) wave, it will reinforce the received signal (voltage). If, however, it arrives exactly 180 degrees out of phase, it will completely cancel it.

In the practical case, neither the maximum of 6 dB reinforcement nor the complete cancellation ever occurs, since the ground is never a perfect reflector. Also, the reflected wave rarely reaches the unreflected wave exactly in phase or exactly out of phase unless the antenna is being used at a frequency exactly that of the design frequency. The effects of the ground reflection will be treated separately from those due to antenna length and tilt angle.

A computer can be used to observe the effect of changing certain parameters. However, it is much easier to see such changes by means of a graphical method Donald Foster described in the October, 1937 issue of the *Proceedings of the IRE*. "If the direction of zero and maxima of K^2 (the radiation function) are plotted on a spherical blackboard with the rhombus at the center, they consist of a coaxial system of small circles, of alternating maxima and zero . . . around one arm of the antenna as an axis, and an identical system of circles around the other arm of the antenna. The angle between the axis of the circles is the angle 2A (see **fig. 3A**) of the rhombus. This pattern on the sphere is ideally suited to representation on the plane by means of the sterographic projection."[7]

While his method probably sounds complicated, it actually summarizes a very simple and easily grasped idea of what happens as the parameters are changed. Antenna enthusiasts will recognize the "zero and maxima of K^2" as the first null and main lobe of the antenna field intensity graph of "Angle with Respect to Wire Axis vs Length of Wire in Wavelength" shown in figure 15 in the second chapter of the *ARRL Antenna Book*.

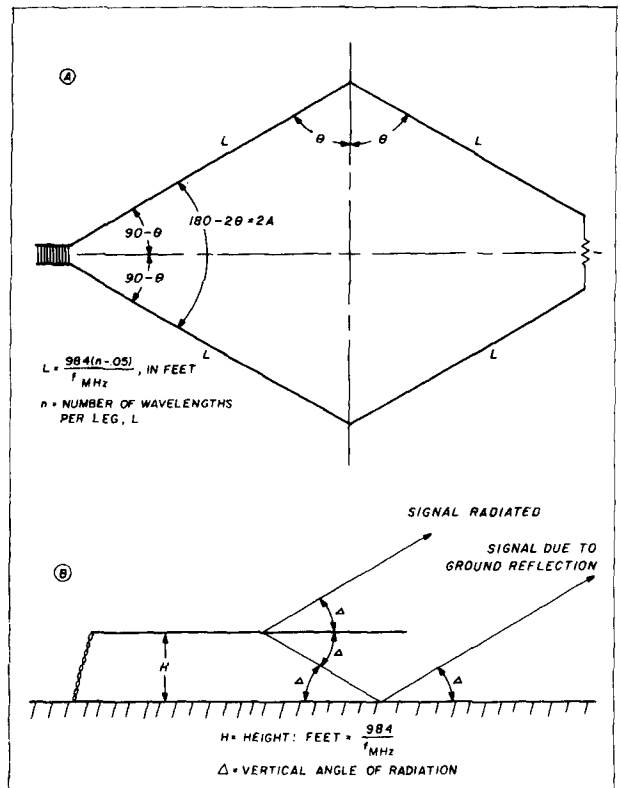


fig. 3. Definition of rhombic antenna parameters. In (A) Length, L, and tilt angle, θ, are actual dimensions of the antenna and affect free-space pattern. In (B), part of the radiated power goes directly from the antenna at angle Δ.

Without going into the mathematics of their construction, the following discussion will help you to make your own stereographic representation.

construction of stereographic overlays

The free-space pattern charts are made by the use of **fig. 4**, which shows the angles of the maxima and nulls in long wires. This is the same as figure 15 of chapter 2 of the *ARRL Antenna Book*, but shows up to the 8th maxima and null instead of just the first.

Step 1. Draw a 6-inch diameter circle and place perpendicular vertical and horizontal lines through its center; refer to **fig. 5**.

Step 2. Lay out 0 to ±90 degree tick marks around the periphery of the circle counterclockwise and clockwise from the right horizontal line intersection of the circle.

Step 3. From the −90 degree position on the perimeter of the circle, draw straight lines to 0, ..., 80, 90 degrees and label the points where they intersect the horizontal line as 0, 10, ..., 70, 80 degrees. For ease of viewing **fig. 5**, only the 20, 50, and 70 degree lines are shown.

The labeled points represent the vertical angle of

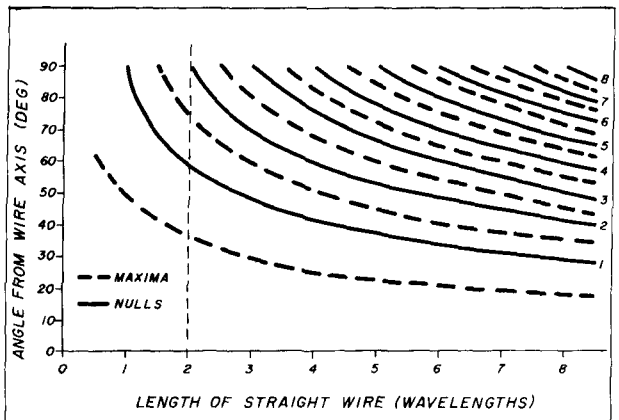


fig. 4. Angles of maxima and nulls in long wires carrying standing waves.

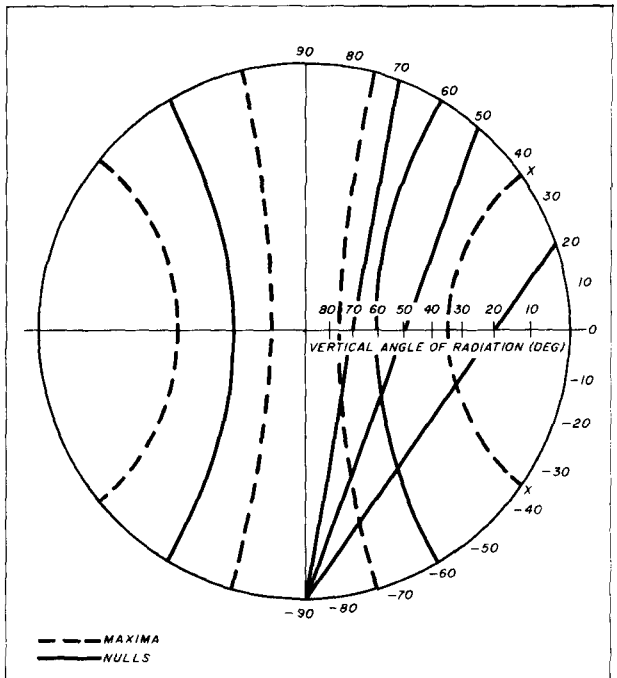


fig. 5. Stereographic map of the radiation pattern for a two-wavelength straight wire in free space.

radiation of the rhombic. It will be necessary for future work to have this as an overlay for a scale for determining the vertical angle of fire of other rhombic designs.

Step 4. Determine the number of wavelengths to be analyzed (2 wavelengths, for example).

Step 5. Using **fig. 4**, draw a vertical line up from the 2 wavelength point to the curve. Read off the indicated value.

Step 6. Tabulate the angle of maxima and nulls from Step 5; maxima at 36 and 75 degrees, nulls at 60 and 90 degrees.

Step 7. Place a mark on the circle perimeter at ±36 degrees. Draw a dotted circle through those two points and the 36 degree point on the horizontal line. The center of that radius must lie on the horizontal line extended to the right of the circle. That dotted line represents the first maximum of a radiating wire two wavelengths long. Repeat for ±75 degrees, which represents the second maximum. Repeat the same two angles from the left side of the chart, which represent the reverse direction of fire.

Step 8. Place marks at ±60 and 90 degrees and draw solid-line curves, which represent the first and second nulls respectively. Repeat for the reverse direction.

You now have a one-leg pattern of a two-wavelength long rhombic. You will need two of them for analysis, as will be explained.

A ground reflection overlay is also needed and is made as follows.

Step 1. Draw a 6-inch diameter circle with a perpendicular horizontal and vertical line through its center; see ***fig. 6.***

Step 2. Determine the number of wavelengths above ground the antenna is to be placed (one wavelength, for example).

Step 3. Using **fig. 7**,[8] tabulate the null and maximum vertical angles of radiation for the chosen height. For one wavelength (360 degrees) we have 15 degrees, 48 degrees maximum and a 30 degree null.

Step 4. Place the scale for determining the vertical angle of fire of the rhombic under the 6-inch circle and place a mark on the horizontal line at the 15 degree, 48 degree, and 30 degree vertical angle of fire points.

Step 5. Draw dotted-line circles through the 15 and 48 degree marks using the center of the 6-inch circle so as to produce concentric circles. Draw a solid-line circle through the 30-degree line in the same manner. The dotted circles represent the first and second maxima, and the solid line represents the first null.

The three stereographic maps are all that are required to design a two wavelength on a leg rhombic mounted one wavelength above the ground. All other maps are made the same way for different leg lengths and heights.

During World War II Richard Bluhm, W2KXD, adapted Foster's graphical method to make it practical for use by the average person. In an unpublished paper[9] written in 1944, he provided a means of rapidly designing horizontal rhombic antennas using Foster's stereographic overlays. Even though the data obtained by his method is not precise, results obtained during wartime erection of rhombics by the military bear out mathematical calculations with excellent accuracy.

The design of my rhombic is based on W2KXD's method. In discussions with him, we both felt that his

stereographic charts (almost 50 in number) should be available to Amateurs interested in designing and constructing rhombics.*

Figure 5 is the stereographic representation of the free-space radiation function of one leg of a rhombic antenna. The length of this leg is two wavelengths. Let's review it for emphasis. Looking from right to left on **fig. 5**, there is first a dotted line, then a solid line, then a dotted line and so forth. The dotted curves represent the maxima circles described by Foster. The solid curves represent the zero circles. A drawing identical to **fig. 5** is then superimposed on the drawing shown in **fig. 5**. Each represents the radiation function of a two-wavelength leg of a rhombic antenna.

Suppose it is desired to have a tilt angle of 70 degrees. From **fig. 3A** we can calculate 2A = 40 degrees. By rotating the superimposed drawings so that a 40 degree angle is realized between the axes of the two legs, we obtain the actual free-space radiation pattern of a rhombic antenna with two wavelength legs, and a tilt angle of 70 degrees; see **fig. 8**.

By studying **fig. 8**, it can be seen that the first dotted lines of the two drawings intersect at point X; that is the main lobe. Next, consider the first dotted line of the lower leg and note that it intersects the second dotted line of the upper leg at point Y. The second dotted line of the lower leg intersects the first dotted line of the upper leg at point Z. Other points of intersection are at points A, B, C, D, E, F, and G as shown in **fig. 8**. These intersection points of the dotted circles represent points of maximum radiation, or lobes, of the antenna.

A line drawn from the center of the figure through point X is extended to the edge of the great circle. This line is now called "the axis of the antenna," and is the line in which the strongest lobe of the rhombic lies. The strongest, or main lobe of a rhombic will always fall exactly midway between the two legs of the antenna if it is designed correctly.

The next step is to number the dotted curves at the periphery of the circle for ease of handling. The dotted lines of the upper leg are numbered 1, 2, 3, and 4, starting with the lower end of the first dotted line and going clockwise. The dotted lines of the lower leg are also numbered 1, 2, 3, and 4, but starting at the upper end of the first dotted line, and going counterclockwise.

When a Number 1 curve intersects another Number 1 curve, the resulting point is that of maximum radiation of the antenna. Other intersection points, called minor lobes, do not reach the level of the (1,1) intersection point. For instance, (refer to **table 1**), a Number 1 dotted curve intersecting a Number 2 dotted curve, points Y and Z on **fig. 8**, gives a lobe which is 10.6 dB lower in level than a (1,1) intersection. A (2,2) intersection point A on **fig. 8** is 21.1 dB lower

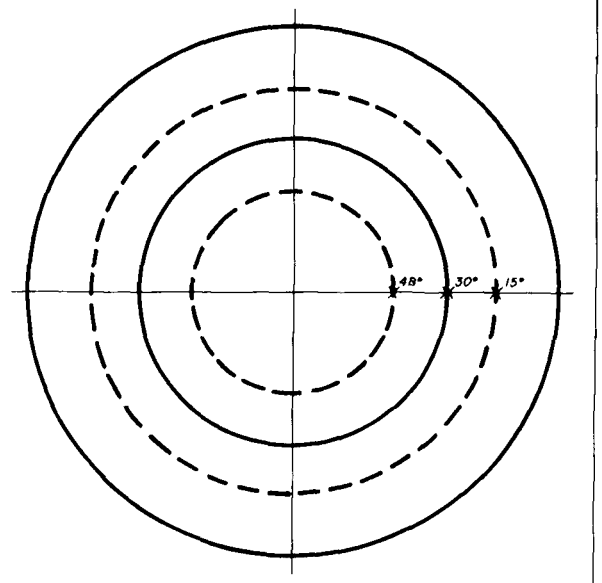


fig. 6. Ground interference pattern; antenna height one wavelength.

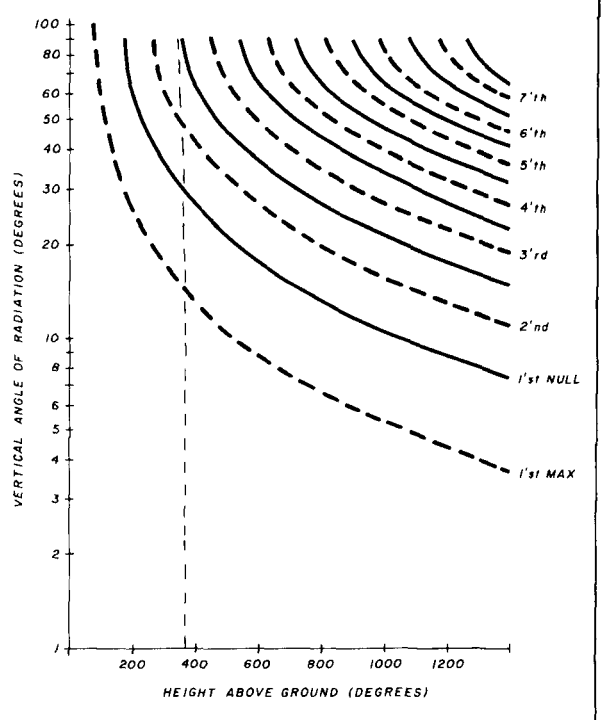


fig. 7. Vertical radiation angle vs. maximum and null angles for various antenna heights in electrical degrees.

*A complete set of approximately 50 8½ by 11 inch overlays may be obtained from the author. These overlays are in photocopied form and will have to be made into transparencies for actual use. — **Editor.**

table 1. Decibel differences between main lobe and subsequent minor lobes on rhombic antennas.

	rhombic radiation lobes										
	1	2	3	4	5	6	7	8	9	10	11
1	0										
2	10.6	21.1									
3	15.1	25.6	30.10								
4	18.0	28.6	33.10	36.0							
5	20.2	30.8	35.25	38.2	40.40						
6	21.9	32.5	37.00	40.0	42.10	43.9					
7	23.4	34.0	38.50	41.1	43.60	45.3	46.8				
8	24.6	35.2	39.70	42.6	44.80	46.6	48.0	49.3			
9	25.7	36.3	40.80	43.7	45.90	47.7	49.1	50.4	51.4		
10	26.7	37.3	41.75	44.7	46.90	48.6	50.1	51.3	52.4	53.40	
11	27.6	39.2	42.60	45.6	47.75	49.5	51.0	52.2	53.3	54.25	55.1

power difference (dB)

in level than the (1,1) intersection. The (4,4) intersection, point G is 36 dB lower, and so forth.

As the number of wavelengths on a leg increases, the number of dotted curves increases. For a composite overlay of two ten-wavelength legs, there will be twenty dotted curves per leg. **Table 1** gives levels only up to the eleventh curve since the minor lobes beyond this point are so weak in comparison to the main lobe as to be negligible. If at any time a solid curve intersects two dotted curves at or near their intersection, the lobe made by these curves intersecting will be cancelled or considerably reduced. That holds true in all cases. For instance, the (1,2) intersections, or the Y and Z points in **fig. 8**, are very close to the outside circle, which represents the horizon. Since these two lobes are depressed to just above the horizon, they may be considered as absorbed by surrounding hills or buildings, so that they will be of little use.

To find the vertical angle of fire of each of the lobes, **fig. 9** is superimposed on the drawings. **Figure 9** is the scale used for determining the vertical angle of fire for the various lobes of the rhombic antenna. When **fig. 9** is placed coincident with **fig. 8** (all figures are transparent), the main lobe, point X, will be at a 30 degree vertical angle of fire. Points Y and Z have about 5 degree vertical angle of fire, which is too low to be usable except at the higher frequencies. Point A has about a 73 degree angle, points B and C about 90 degrees, and so forth.

The great thing about this stereographic method of analysis is that angle 2A between the two legs can be easily changed. As the angle is made greater, the two legs move apart, the main intersection travels out toward the horizon, and the vertical angle of radiation becomes less. Angle 2A can be increased until the intersection of the number one dotted curve reaches the horizon with a vertical radiation angle of 0 degrees. Further separation between the two legs causes the main lobe to split into two lobes. Although not obvious, the two split lobes are excessively sharp horizontally; yet despite this sharpness, the gain must necessarily be very low. Some of the minor lobes will have magnitudes as great or perhaps greater than the main lobe. The energy of the system is leaking out through other lobes in other directions rather than being concentrated in the main lobe. It might be difficult to discover this situation by arithmetical computations, but it is quicky observed by using stereographic charts. For a fixed rhombic beam, the upper frequency use is limited at the point at which the beam splits.

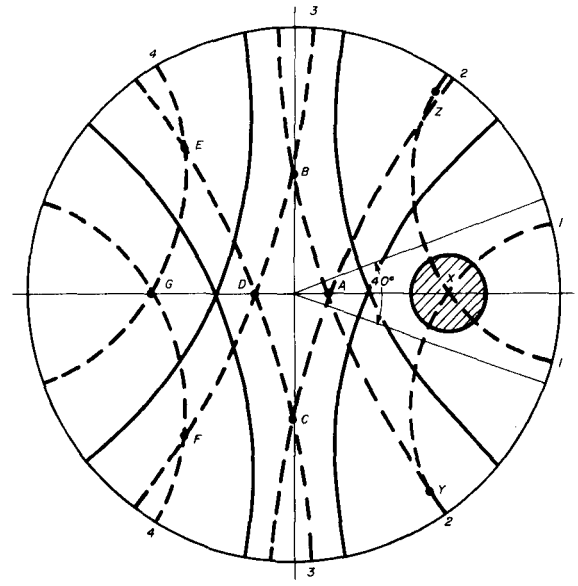


fig. 8. Free space pattern, two-wavelength. Note: the horizontal and vertical lines are for reference to the antenna plane only and are not seen in the overlays.

ground reflection effects

We must now consider the ground reflection or

ground interference effects on the free-space pattern of the two wavelength rhombic discussed above. To keep it simple, an antenna height of one-half wavelength will be used; it has only one reflection agent. **Figure 10** shows the ground pattern, which is the dotted circle, for one-half wavelength high antenna superimposed on **fig. 8**. Dotted lines represent an in-phase reflection reaching the antenna, whereas solid lines represent cancellation. The one-half wavelength height has no out-of-phase reflection radiation.

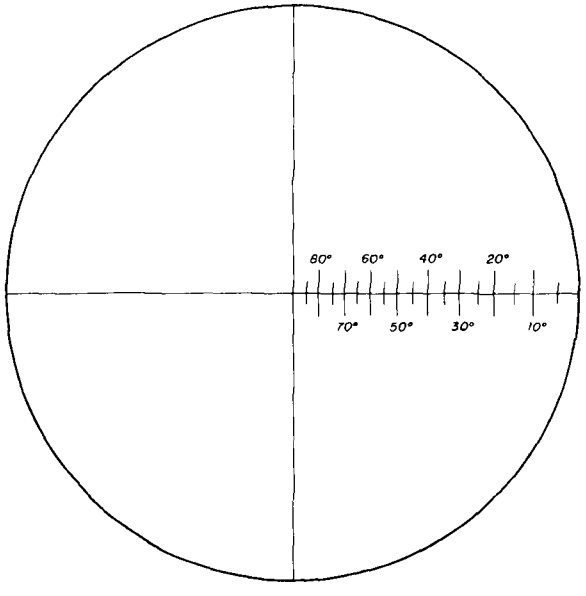


fig. 9. Scale to determine vertical angles of fire on rhombic antennas.

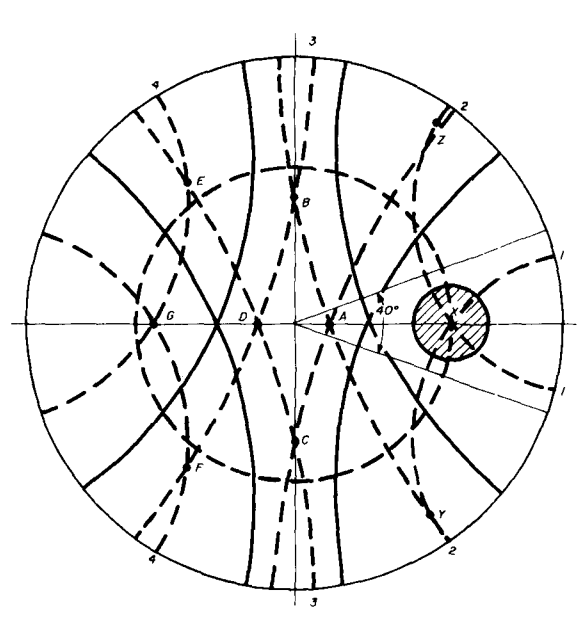


fig. 10. Superimposition of two-wavelength rhombic free-space pattern and one-half wavelength height ground interference pattern.

Note that the dotted circle intersects the free space antenna pattern exactly at point X, which is the main lobe point. (This happened only because the problem was done before writing this article, of course). That means the in-phase reflection has arrived to reinforce the main lobe. As noted previously, an additional 6-dB reinforcement of the main lobe has occurred. Points Y and Z of **fig. 10** are quite distant from the dotted circle and therefore are not reinforced. That means the main lobe has now increased to 16.6 dB instead of only 10.6 dB stronger than the next two strongest lobes (Y and Z) merely by choosing the correct antenna height.

Point A, the next strongest lobe, has not been reinforced by ground reflection and consequently has also been reduced with reference to the main lobe. Points B, C, E, F, and G are relatively close, however, to the reflection circle. While they will not be reinforced by 6 dB, since they are not exactly on the reflection circle, they have been reinforced by perhaps 4 dB so they have only decreased by a matter of, say, 2 dB with respect to the main lobe.

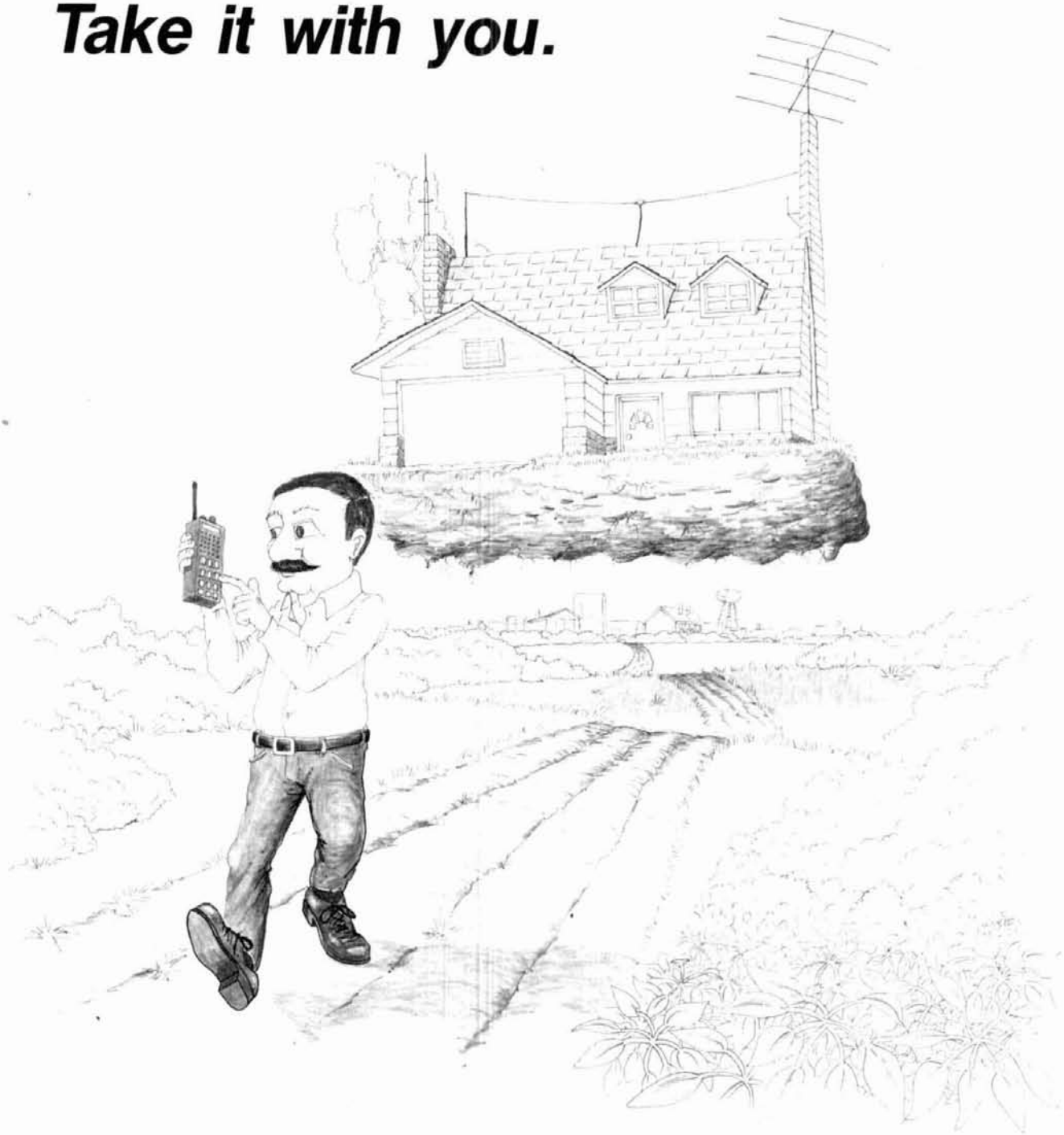
The wavelength height of the antenna may be raised by using higher towers for a given frequency or by increasing to a higher frequency with fixed antenna height. As the wavelength height of the antenna is raised, the number of reflection circles increases, and a number of solid lines representing ground interference appears on the stereographic overlays. For example, at a height of one wavelength, two reflection circles separated by an interference solid-line circle appear. At two wavelengths, there are four reflecting dotted circles and three interference circles. Different ground interference pattern overlays are therefore required.

design of 20-meter rhombic

Now we have an idea of what the use of the overlays can do for us in designing rhombics. Let's apply that information to the design of a rhombic for use on the 20-meter band. We want it to be four wavelengths on a leg and have it one wavelength high. The problem is to determine the best tilt angle for these conditions. Note that this is not the proper way to start a rhombic antenna design. The proper way is to first determine the radio circuit path desired, and therefore the desired vertical angle of radiation between the transmitting and receiving stations; review reference 8. Then design the rhombic to include that radiation angle. However, the stated problem will best review the use of the stereographic overlays, permitting you to do what you really want to do.

Superimpose two "leg pattern — four wavelengths"

Take it with you.



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and one "ground interference pattern — one wavelength." Rotate the two leg pattern overlays so that their (1,1) curves intersect at the outermost dotted circle of the ground interference chart. Measuring the angle between the two legs, we find it to be 42-1/2 degrees, which is the angle 2A of **fig. 3A**. The tilt angle, θ, will be calculated to be 68-3/4 degrees. If the scale for determining the vertical angle of fire, **fig. 9**, is placed on the other charts, it shows the vertical angle of radiation for our rhombic to be 14 degrees. **Figure 11** shows the resulting composite of the overlays, first maxima only.

All the essential design factors of the rhombic have been found. They are: leg length = four wavelengths; height = one wavelength, tilt angle = 68-3/4 degrees, angle of fire = 14 degrees. The relative strength of the minor lobes and the front-to-back ratio can be found by referring to **table 1**. The front-to-back ratio in this case is about 51 dB. This is found by determining the intersection of the last two dotted curves which lie on the line extending in back of the main lobe. These will always be the dotted curves nearest the left-hand edge of the solid circle of the leg patterns (not shown in **fig. 11**). In this case they are the Number 8 curves counting from right to left on the leg patterns. Referring to **table 1**, the lobes produced by the intersection of the Number 8 curves or (8,8) point is 49.3 dB weaker than the main or (1,1) lobe. The main lobe has a ground reinforcement of 6 dB. Because the ground reflection pattern does not pass directly through the (8,8) lobe, but only near it, a ground reflection of about 4 dB will accrue. The difference between these two reinforcements is thus 2 dB, which further increases the front-to-back radio to 51.3 dB. In round numbers, this is about 51 dB. The vertical angle of radiation of the (8,8) lobe is about 22 degrees.

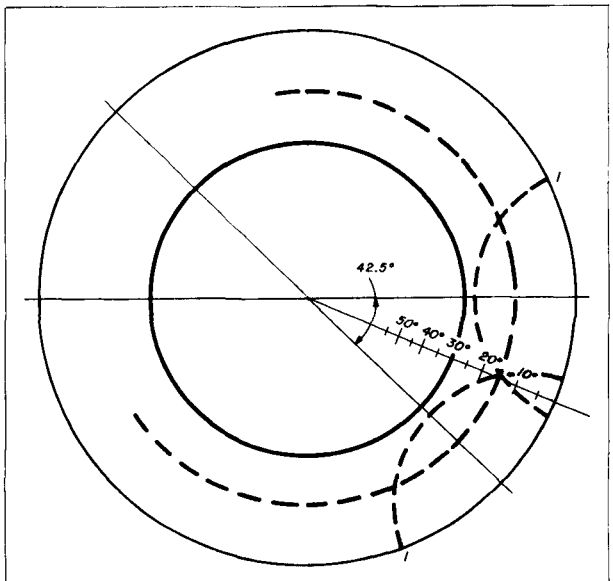

fig. 11. Overlay of two two-wavelength leg patterns, a ground interference pattern one wavelength high, and scale for determining vertical angle of radiation. Intersection with the first maximum ground interference line of first maximum (1,1) produces a 2A = 42-1/2 degree angle, and a vertical angle of radiation of 14 degrees.

Note that there is a (7,7) rear lobe falling exactly on the second ground reflection circle. However, the vertical angle of radiation is about 48 degrees, which will probably be lost into space at 14 MHz.

determination of vertical and horizontal radiation patterns

Figure 12 duplicates **fig. 8**, but with many lines eliminated to make the figure less "busy." Radial lines have been drawn from the center of the figure through each lobe point and extended a distance beyond the horizon circle. Starting at the axis of the antenna, the angle between the lobes is measured and recorded. These radial lines at the recorded angles are then reproduced on polar coordinate paper; see **fig. 13**. The radial lines at their correct angular displacement from the axis of the antenna are marked with their corresponding dotted line intersections. That is, the axis of the antenna will be marked with (1,1) and (2,2) because the Number 1 dotted curves and the Number 2 dotted curves have their intersections on that line. The other lines are similarly marked.

Next the ground interference pattern for an antenna height of one-half wavelength as shown in **fig. 10** is examined and the strength of all lobes as previously discussed (**table 1**), are tabulated. They are:

(1,1) =	0 dB	(3,3) =	−30.1 dB
(2,1) =	−16.6 dB	(4,3) =	−35.1 dB
(2,2) =	−21.1 dB	(4,4) =	−38.0 dB
(3,2) =	−27.6 dB		

The scale on the polar coordinate paper is then laid out from 0 dB through 50 dB in 10-dB increments; see **fig. 13**, and the lobes are plotted with reference to these circles.

This is only a relative pattern because it does not take into account the effect on the pattern of the different vertical angles of fire. For instance, the (2,1) lobes are greatly attenuated because of their low angle of fire, resulting in absorption by surrounding hills or buildings if in the vicinity of the antenna. However, the pattern does show the relative strengths of the peaks of the lobes in the horizontal plane and should prove very useful.

The determination of the strengths of the lobes at any point on, with the exception of the peak, is not readily determined through the use of the stereographic projection. The horizontal angle covered by the major lobe may be roughly found by drawing a

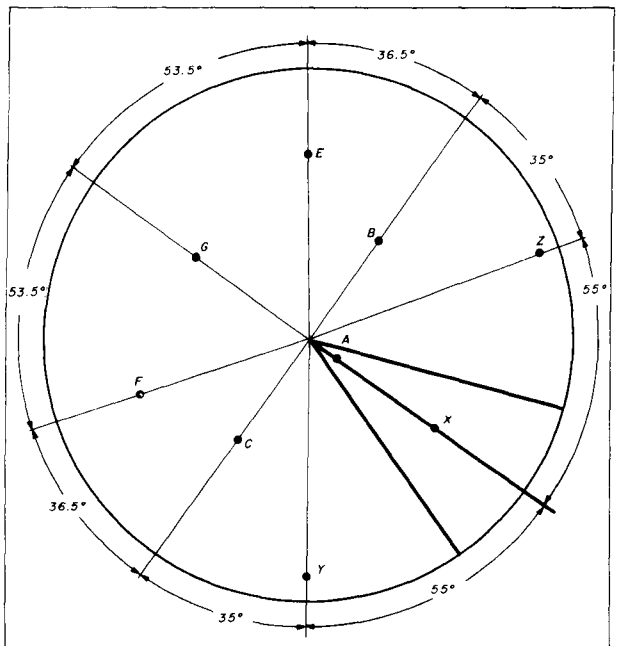

fig. 12. Same as fig. 8, but with intersection points only shown with angular displacement of intersections from main lobe direction.

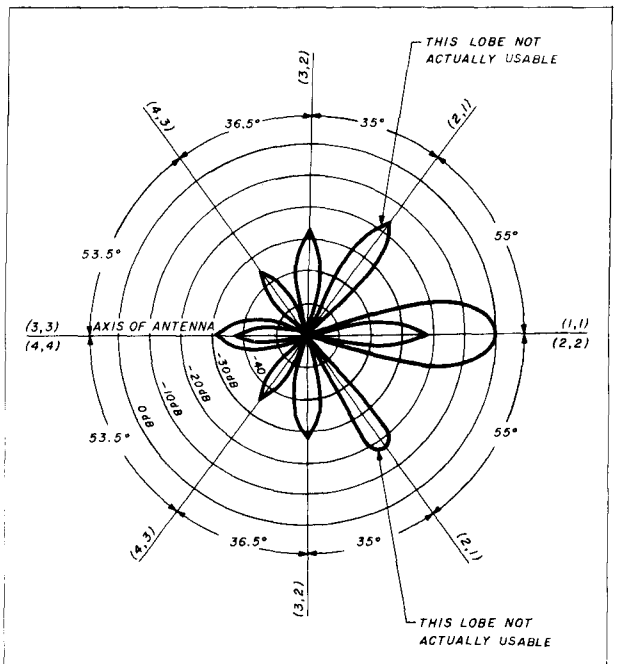

fig. 13. Horizontal plane pattern for two-wavelength rhombic antenna. ϕ = 70; antenna height = one-half wavelength.

circle with the center at the (1,1) intersection, (or at the center of the spherical triangle formed by the intersection of Number 1 curve and the ground interference circle, depending on whether all three curves intersect in one point or not) and a radius equal to one-half the distance between the intersection (or spherical triangle) and the nearest solid null curve. Lines tangent to this small circle drawn from the center of the large circle will form an angle which is a rough estimate of the usable horizontal beam width. On **fig. 8**, the small shaded circle is the circle mentioned above. The beamwidths of the minor lobes are not readily obtainable, but this should not prove objectionable since the major lobe is the only one which is used in most of the cases.

The vertical plane diagram is constructed in a similar manner as the horizontal pattern, except that **fig. 9** is used to determine the vertical angles. These are:

(1,1) = 29 degrees	(3,3) = 75 degrees
(2,1) = 7 degrees	(4,3) = 27 degrees
(2,2) = 75 degrees	(4,4) = 30 degrees
(3,2) = 35 degrees	

This gives some interesting results. Above about 7 MHz the (2,2) and (3,3) lobes may be considered useless since they will penetrate the ionosphere at such high angles. As previously stated, the (2,1) lobes are radiated at such a low angle as to be useless on all but extremely local signals or at extremely high frequencies.

Returning to the vertical plane pattern, radial lines are again laid out, only this time the vertical angles of fire are used in place of the horizontal radiation angles. All those lobes falling to the left of the center of the circle are plotted to the left and all those falling to the right are plotted to the right. Those falling to the left will be (3,3), (4,3), (3,2) and (4,4). Those falling to the right will be (1,1), (2,1) (3,2) and (2,2). Since the (3,2) lobes fall exactly on the center line of the circle, see **fig. 8**, (axis of the antenna being horizontal) one will be plotted to the left, and one to the right. This is not a strictly accurate geometrical layout of the pattern but will suffice since the determination of the relative strengths of the lobes in the vertical plane is all that is desired. The levels determined for the horizontal plane pattern may be used, without change, for the vertical plane pattern. The complete vertical plane pattern is shown in **fig. 14.**

Through the use of different height curves, leg length curves, and tilt angles, unwanted lobes may be eliminated or effectively reduced and desired lobes may be reinforced. The use of leg lengths longer than eight or ten wavelengths is inadvisable because of the subsequent reduction in width and height of the radiated lobes. A reduction of this sort is conducive to fading and makes the aiming of the antenna extremely critical.

A compass rose may be superimposed on the drawing as an aid in determining the angle between the legs of the antenna and the angles between the main lobe and the minor lobes. The use of an angle between the

table 2. Beamwidth as a function of leg length. Beamwidth is the point where power is 3 dB down from the maximum power point.

leg wavelength	beamwidth (degrees)	number DXCC countries within beamwidth forward direction (from North Carolina)	reverse direction
1	30	84	4
2	25	77	4
4	17	63	4
6	10	43	4
8	8	40	4
10	6	35	3

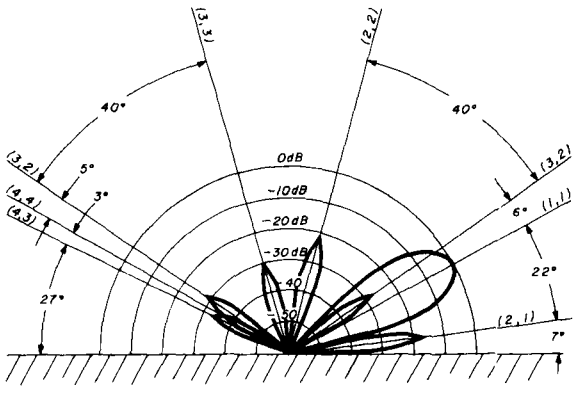

fig. 14. Vertical plane pattern for two-wavelength rhombic antenna. ϕ = 70; antenna height = one-half wavelength.

legs, such that the two Number 1 curves do not intersect, should be avoided, because this will effectively eliminate the major lobes, which is the most effective source of power from the rhombic antenna.

multiband operation

One of the most useful features of a rhombic antenna, as previously mentioned, is its ability to operate efficiently over a wide frequency range. The two-wavelength rhombic illustrated in **fig. 8** will be used as an example. Suppose it is desired to operate this antenna on 4 MHz. Its legs will then be two wavelengths long and its height will be one-half wavelength. On 4 MHz, using the formulas of **fig. 3**, two wavelength legs will be 485 feet long, and the height of the antenna will be 123 feet. Now, if the operating frequency is made 8 MHz, the length of the legs will be four wavelengths long at this frequency, and the antenna height will be one wavelength. Suitable overlays for the leg length and antenna height for this frequency are now set up, retaining the 70 degree tilt angle previously used. The major lobe will now be found to have an angle of fire equal to 15 degrees which is approximately the optimum angle of fire for 8 MHz. The horizontal azimuthal angle covered by the major lobe has now been reduced to 17 degrees instead of the original 25 degrees. The antenna will work practically as well, therefore, on 8 MHz, as it does on 4 MHz. The only change worth noting is the reduction of the beamwidth, since the 15 degree angle of fire is about optimum for 8 MHz, as is the 30 degree angle for 4 MHz.

Suppose the frequency were now increased to 12 MHz. The legs will now be six wavelengths long and the height will be one and one-half wavelengths. The pattern is again set using the appropriate overlays. It will be noted that the two (1,1) curves, depressed to the horizon, form a spherical triangle with the first ground interference circle. While this materially reduces the strength of the major lobe, it is still usable. The angle of fire is taken from the center of the spherical triangle and is found to be about 7 degrees. While this is rather low for 12 MHz, it will work fairly well in locations where the antenna is well out in the clear and away from any trees or buildings. This rhombic antenna, therefore, may be said to be extremely effective over a 2 to 1 frequency range (4 - 8 MHz) and fairly effective over a 3 to 1 frequency range (4 - 12 MHz). It would work over any 3 to 1 frequency range, 6 to 18 MHz, 8 to 24 MHz, or any similar range. Of course appropriate leg lengths and heights would have to be used for two wavelength legs and one-half wavelength for the lowest frequency.

beamwidth

The beamwidth of a rhombic is generally a function of the leg length. **Table 2** indicates beamwidth versus leg length. Beamwidth is defined as the angle where a 3 dB loss has occurred from the maximum power point. From Salisbury, North Carolina, with the rhombic pointed at approximately 47 degrees from north, which is the bearing for London, England, many countries can be worked as shown in **table 2**.

By switching the feedpoint to the rhombic including the terminating resistor, to the opposite end of the

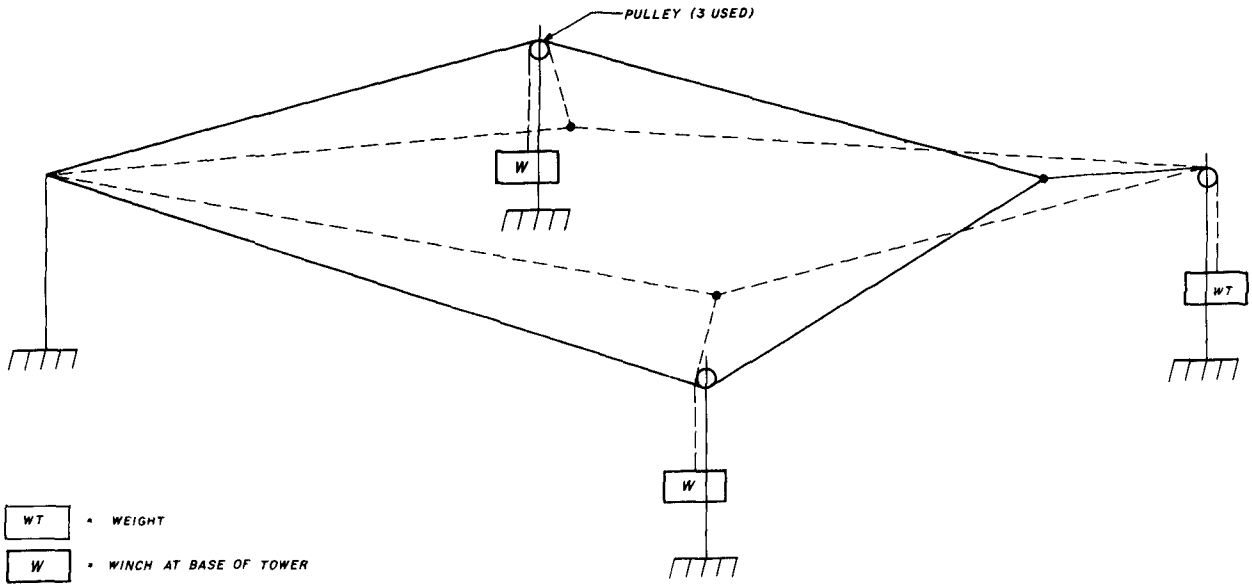

fig. 15. A controlled vertical radiation (CVR) rhombic antenna showing extremes between lowest frequency use (solid lines) and highest frequency use (dotted lines.).

rhombic, its direction of fire will be reversed 180 degrees. **Table 2** also shows the number of DXCC countries workable within the stated beamwidths in the reverse direction — not very many. It is, however, a "pipeline" through Mexico, Pitcairn Island, Clipperton, and MacQuarie. With a rhombic on Japan, South America should be blanketed in the reverse direction. Unless you are interested in a particular point-to-point radio path, rhombics longer than 10 wavelenths are too narrow for general use.

controlled vertical radiation rhombic

Now that you know how to design a rhombic antenna, let's move on to a more specific aspect of design, the controlled vertical radiation (CVR) rhombic. Bruce and Beck, in the April, 1935 *Proceedings of the IRE*[10] described experiments made with a steerable rhombic during reception of transoceanic shortwave signals. The first and last I'd read about it in Amateur Radio was an article in April, 1937, issue of *QST*.[11] In this account, W6AUX and W7CNX reported on their operation of a CVR rhombic in the 20-meter band. While not claiming anything new, I am expanding the CVR principle to provide a rhombic that can operate at a design efficiency anyplace in the Amateur bands with a limitation only on the minimum acceptable beamwidth.

A CVR rhombic is simply a rhombic whose shape may be changed by physical means; see **fig. 15**. By having pulleys on the side towers and one end tower,

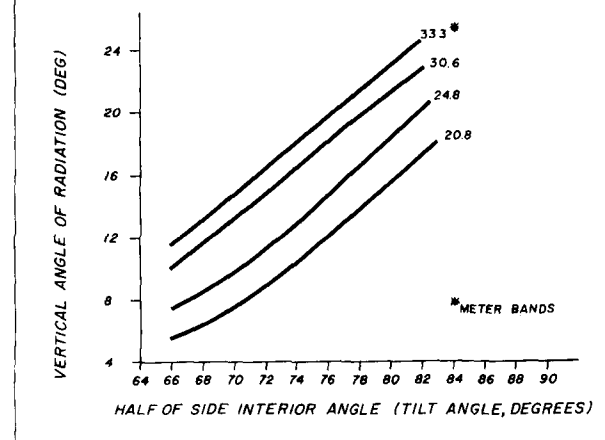

fig. 16. Change of vertical angle of radiation with change of tilt angle for various operating frequencies. (By E. Bruce in 1935.)

the tilt angle of the rhombic may be changed and set to any desired number of degrees.

Let's see what Bruce and Beck say about that. They were studying rapid fading in radio circuits, and the possible cause being the interaction of different components of a radio signal having different transmission times. Their past observations had indicated that fading was affected by the directivity of the receiving antenna. Tests in 1934 had shown that a greater degree of angular spread between multiple path waves exist in the incident vertical plane than in

the horizontal plane. So they devised a rhombic of the type of **fig. 15** and ran extensive tests. Their article concludes, "It is believed that the results, discussed in this paper, demonstrate that sharp angular discrimination is a basically sound method of combating selective fading."

Of greater interest to Amateurs is not the minimizing of fading, but the fact Bruce's and Beck's tests showed that the vertical angle of radiation from a rhombic can be varied 12 to 14 degrees for a given frequency. While it's possible to do that with a Yagi antenna by raising and lowering its tower, how many hams would want to do that? The compromise — a good one — is to have a high Yagi for long-haul or band-opening contacts, and a low one for staying within the skip zone into Europe when the band is wide open. However, we're talking about a rhombic with superior gain over a Yagi when the rhombic is operating at its peak.

Figure 16 is a copy of the Bruce/Beck curve showing steerability, at several wavelengths, of the horizontal rhombic antenna used for fading reduction studies. We can call it the vertical radiation angle versus the rhombic tilt angle. Think about setting your rhombic on 20 meters for a 7 degree vertical angle of radiation as sunrise approaches to get real long haul or early band openings, and then as the day continues, changing the radiation angle to 12 degrees or more to put a commanding signal into Europe when the band is fully opened. When motorized, it would be possible to tune the antenna for maximum received signal strength from the desired location.

In the 1937 *QST* article, using the same idea, Moore and Johnson concluded the following:

1. *That there is an optimum angle in the vertical plane for transmission as well as reception.*
2. *That the optimum angle for transmission and reception are close together although not necessarily coincident.*
3. *That there is, under normal conditions, only a very limited region in the vertical plane in which useful radiation takes place, and that energy directed into any other region in the vertical plane is largely wasted.*
4. *That the optimum angle of transmission changes from time to time with changes of seasons and conditions, but that there is no material change within a short interval of time.*
5. *That controlled directivity in the vertical plane is relatively more important than directivity in the horizontal plane.*[11]

Now that rotatable arrays are the accepted thing, the fifth claim is debatable. However, in the 1930's one would have assumed Bruce and Beck meant that the proper vertical angle of radiation to a given point is more important than the gain of the antenna; gain and directivity, at that time, seemed to have been synonymous. A very high gain antenna whose vertical angle of radiation over-shot the desired reception point would be a poor performer in comparison to a dipole whose vertical angle of radiation was such as to give maximum reception at the receiving point.

From earlier discussions, we have learned that the vertical angle of radiation does change as we vary the tilt angle of the rhombic. That change is very easy to see with the stereographic overlays. Unfortunately for the earlier investigators, Foster did not publish his works until October, 1937.[7]

We must not be left with the impression that we are getting something for nothing when we change the vertical angle of radiation by tuning the tilt angle. If you recall the analysis section above, you will remember that the tilt angle during design is adjusted to fall on a dotted circle of the ground interference pattern to give a 6 dB boost from the ground reflected signal. By tuning the tilt angle during operating periods, that ground reinforcement deteriorates. However, this is where point five of the Moore/Johnson[11] conclusions becomes important; controlled directivity in the vertical plane is more important than gain in the horizontal plane. Since we can tune the tilt angle for maximum received signal, the law of reciprocity of transmitted/received signals says we are at the best operating conditions for the radio path in use.

The most interesting thing about being able to change the configuration of the rhombic is the ability to tune the antenna to the operating Amateur band desired. It was earlier stated that a fixed rhombic can be made to work reasonably well over a range of frequencies of 3 to 1. As the frequency gets higher, the vertical angle of radiation gets lower until at some frequency the main lobe splits and the rhombic no longer has high operating performance.

The CVR rhombic can be adjusted for peak performance at any Amateur band. For example, if for a given arrangement, the antenna frequency is increased to the lobe splitting point, it is necessary only to lengthen the overall configuration to raise the vertical angle of radiation and bring the split lobes together again at the higher frequencies.

RF feed to a rhombic

This discussion of feeding RF to the rhombic is based on the understanding that the antenna will be terminated in its characteristic impedance. By so terminating it, we can take advantage of the excellent front-to-back ratio that distinguishes this antenna from other types, as discussed earlier. The method of termination will be discussed later.

The antenna input impedance changes with frequency even when terminated. Various authorities

show that an impedance change occurs from as much as 850 ohms to 600 ohms over a frequency range of 4 to 23 MHz. However, because of the relatively small percentage change, the worst SWR based on a center impedance of 750 ohms would be 1.25:1. So the problem boils down to getting from the transmitter output of 50 ohms to the antenna's 750 ohms (see **fig. 17**).

It can be seen that the main transmission feeder line is a 600 ohm, two-wire open line, with provisions to feed either end of the rhombic antenna. A switching arrangement at the center of the antenna permits exchanging the RF feedline and dissipation line to allow remote switching of direction of fire while maintaining a high front-to-back ratio in the chosen direction.

You can get to 600 ohms from 50 ohms immediately by using a 12:1 ratio balun. Barker and Williamson makes a 5 kW 12:1 balun; you can also wind your own. Six hundred ohms for the main transmission line was advisable in my case because of the availability of a 118 watt, 600-ohm type CX. The Globar Division of The Carborundum Company makes a non-inductive resistor that can be used in conjunction with the dissipation line as the termination resistance.

Impedance changes from 750 ohms to 600 ohms are required to get to the 600-ohm line from the two ends of the rhombic. A transmission line whose characteristic impedance is gradually tapered from one value to another may be used as a coupling transformer providing the change in impedance along the line is sufficiently gradual.

When a tapered-line transformer with a minimum length is desired, the characteristic impedance must be tapered exponentially between the two limiting values. One can avoid complicated design computations by using an exponentially tapered line section at least one-half wavelength long at the lowest frequency to be transmitted and connecting it directly between the antenna and the transmission line. Such a line was used between the 750-ohm antenna input and the 600-ohm main transmission line. Since I wanted to use the rhombic on 80 meters, a half-wave exponential line of 137 feet in length was constructed for each end of the rhombic.

rhombic termination

If you don't wish to reverse the direction of radiation of the rhombic, a non-inductive resistor may be installed directly at the far end of the rhombic. The power rating of the resistor should be at least one-third of the power going into the antenna; two-thirds of the input power is radiated before it reaches the far end. For example, if the power to the antenna is 500 watts, key down, the terminating resistor should be able to dissipate about 170 watts.

An alternative is to use a balanced lossy line of high dissipation rating. I used a 600-ohm dissipation line

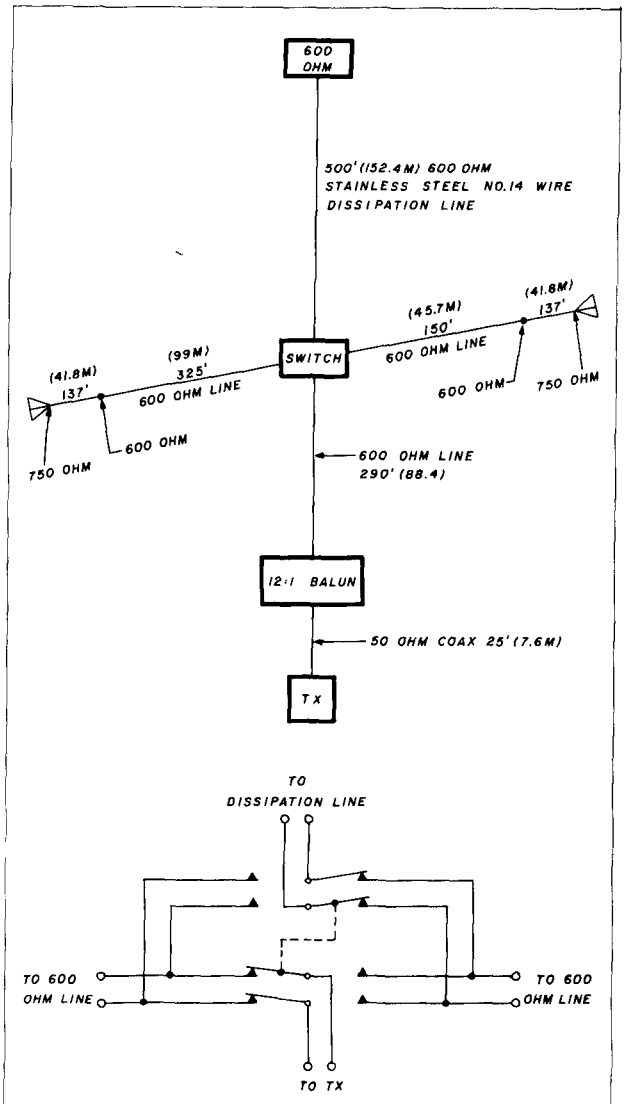

fig. 17. (A) Matching to the rhombic and changing its firing direction is accomplished by using a 12:1 balun, transmission line switch and dissipation line. (B) Transmission line changeover requires an effective 4 PDT switch.

(No. 14 Stainless Steel wire) 500 feet long. The 600-ohm, 118-watt non-inductive resistor terminates the line. As seen in **fig. 17**, remote controlled switching circuits permit swapping of the transmitting and dissipation line to permit reversing the direction of fire of the rhombic.

motorized configuration changer

Figure 15, previously referred to, is a very simplified picture of how to change the configuration of the rhombic. However, because the motorizing of the configuration change by remote means was the most difficult part of the project to develop successfully, some guidelines may be useful.

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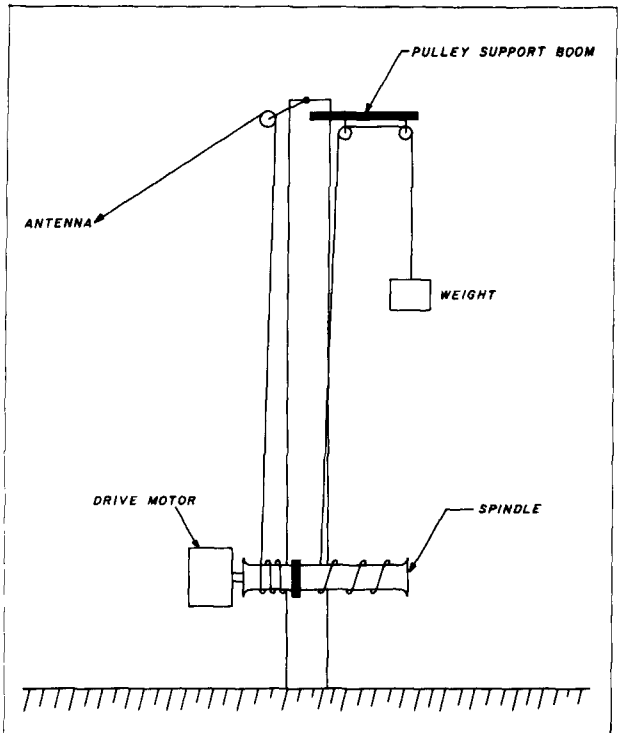

fig. 18. Counterbalancing system to reduce motor drive load.

The first attempt to motorize the configuration was done by a motor at the far end of the array with the weights on the side tower to maintain proper tension in the antenna as the configuration was changed. Don't do it that way! As the rhombic becomes "longer," its legs approach a straight line. The force required to pull the rhombic becomes increasingly greater and a very large motor is required. A better way is to pull the legs in from the side as depicted in **fig. 15**. An analogy is the difficulty in tightening a violin string as opposed to the ease of plucking it from the middle.

Two identical motors — of only modest power — are required. To further reduce the motor power requirements, a counter-balancing arrangement should be used; see **fig. 18**. Using such a system permits a lower motor output because it must only overcome the difference in antenna force versus the counterweight force as the system moves off its equilibrium point, a point of zero motor output requirement.

The drive motors have to be capable of reversing and require a gear reduction to not only increase output torque, but to give slow spindle speed; a spindle rotation speed of 20-30 RPM is good. A 230-volt reversible motor with integral gearing to give 50 foot-pound torque at a speed of 75 RPM was originally tried. That proved inadequate even with the counterbalancing system. A further gear reduction of 4:1 using a chain drive proved acceptable. That was with a 65 pound counter-balance weight, and a 200 pound far-end weight. A surplus synchro connected to the gear motor drive at the closest-to-the-house side-tower permits remote indication of the configuration at the operating position during dark hours. It was necessary to use a gear step-down arrangement so that the synchro makes only one revolution of the entire configuration change.

acknowledgements

A project of this size cannot be accomplished without help. First I'd like to thank Marshall Etter, W2ER, whose long-distance correspondence gave me a fuller understanding of the practical aspects of rhombic antenna construction gleaned from his many years at RCA Riverhead Receiving Station; his knowledge boosted my confidence as well. Fred McGinnis, WD4KJZ, assisted in handling the lines and furnished muscle as we erected four towers — two 70-footers, one 80-footer, and 70 feet of a 100-footer. (Fred is 70+ years old and I was 63 at the time, so we made a great team.) John Fleming, WD4FFX, put up the last 30 feet of the 100 footer, which I declined to climb. Bill McCune, W2IRC, built the spindles and other mechanical parts and provided assistance and advice in the guying of the towers. Richard Bluhm, W2KXD, gave counsel on the Foster charts and design work. Alan Sielke, a non-ham, gave advice on structural loads on the towers from his civil engineering background and loaned me the transit. Norman Gertz, K1AA, furnished the 600-ohm terminating resistor as well as old military publications pertaining to rhombics. Gene Black, W2LL, furnished the old-style 600-ohm DPDT antenna relays needed for direction reversal. Millie Elwell, KA4ECM, helped in the initial survey of the rhombic towers and contributed encouragement and patience.

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1412	144-148	160	30	–	–
1412G	144-148	160	30	.6	15
2210	220-225	130	10	–	–
2210G	220-225	130	10	.7	12
2212	220-225	130	30	–	–
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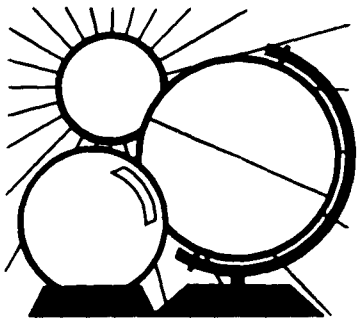

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vernal equinox DX

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Throughout these winter months, the foF2, the major variable factor in calculating MUF (MUF = foF2•factor), is accumulated a little at a time, day by day, and the highest monthly average of the year usually occurs during this quarter. Even during the year of the sunspot minimum, when the solar flux variation is small, an enchanced F2 region can be expected to build up in winter.

Geomagnetic storms during these months, however, may disrupt our midlatitude ionosphere. During the equinoctial months the earth's (dipole) magnetic field is sufficiently perturbed by solar wind particles flowing into the auroral zone at 50-70 degrees north geographic latitude to cause the midlatitude ionosphere to be depleted. Below the auroral zone, the ionosphere develops a trough that extends southward, mainly on the dark side of the earth (i.e., at night) for two to three days in a row. Only near the equator (between ±20 degrees *geomagnetic* latitude) do the geomagnetic disturbances enhance ionization; this is the reason for the higher MUF and ionospheric tilts that give rise to transequatorial (T.E. or one-long hop) propagation. This T.E. is characteristic of the equinoctial months — in the spring more than in autumn — and throughout winter in general.

springtime QRN

March and April are months in which spring storms bring rain to much of the northern hemisphere. Fronts of warm and cold air generate the first major thunderstorms of the year, producing static that reduces the signal-to-noise ratio of received signals, thereby lowering readability.

The cumulative effect of thunderstorm static worldwide is the main cause of high noise levels on the lower frequency HF bands. However, as a storm front approaches your area, a significant increase in the noise level is heard. One first notices this increase at a one-hop distance away (about 600 to 1200 miles or 960 to 1920 km) when the storm front is about one day west of your location. The noise level usually decreases after that until the storm reaches within a ground-wave's distance (50 to 60 miles or 80 to 96 km). Individual discharges can be heard. As the storm draws nearer, its sounds become part of the "local noise;" as it moves away, its noise decreases, then increases again as the front reaches the one-hop distance point a day or so later. (You can correlate this with storm progress reports on local television.) You can save time in looking for rare DX by tracking storms in order to pinpoint when the most favorable listening conditions are likely to occur.

last minute-forecast

T.E. can be expected on the higher frequency bands (10 through 30 meters) during the first two weeks of March. The effect will not be as pronounced as it was last year, but should still provide good transequatorial openings on the higher of these bands. Look for the best openings to occur when the geomagnetic field is disturbed (high A and K figures) toward the end of the second week. The rest of the month will be better for low band night time DX operation. In terms of QRN buildup, this month will be one of the last quiet ones, but only between storms. Spring equinox occurs on March 20th at 1024 UTC. The moon is full on the 17th and at perigee on the 16th.

band-by-band summary

Ten, fifteen, and twenty meters will be open from morning to early evening almost every day, and to most areas of the world. The openings on the higher of the bands will be shorter and will occur closer to local noon. Transequatorial propagation on these bands will be more likely toward evening during conditions of high solar flux and a disturbed geomagetic field.

Thirty and forty meters will be useful almost 24 hours a day. Daytime conditions will resemble those on 20 meters, but skip and signal strength may decrease during midday on days coinciding with high solar flux values. Nighttime use will be good except after days of very high MUF conditions. Generally the usable distance is expected to be somewhat greater than that achieved on 80 at night.

Eighty and one-sixty meters, the nighttime DXer's bands, open just before sunset and lasts until the sun comes up on the path of interest. Except for daytime short-skip signal strengths, high solar flux values have little effect. Geomagnetic disturbances more evident near equinox cause signal attenuation and fading on polar paths. Noise will be very noticeable on these lower frequency bands.

ham radio

MARCH

WESTERN USA

	GMT	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
	PST	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00
ASIA FAR EAST	N	20	20	20	20	20	20	20	20	*20*	*20*	*20*	*20*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	30	30	30	20	20
	NE	20	20	20	20	20	30	30	30	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	30	30	30	20	20
	E	15	15	15	20	20	20	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
EUROPE	SE	10	10	10	10	10	10	15	15	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	15	15	15	15	15
	S	15	15	15	15	15	20	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
	SW	10	10	10	10	10	15	15	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
	W	10	10	10	10	10	15	15	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
	NW	20	20	20	20	20	20	20	20	*20*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	30	30	30	20	20
S. AFRICA		15	15	15	20	20	20	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
S. AMERICA		10	15	15	15	15	15	15	15	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	15	15	15	15	15
ANTARCTICA		15	15	15	15	15	20	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
NEW ZEALAND		10	10	10	15	15	15	15	15	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	15	15	15	15	15
OCEANIA AUSTRALIA		10	10	15	15	15	15	15	15	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	15	15	15	15	15
JAPAN		20	20	20	20	20	20	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20

MID USA

	MST	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00
ASIA FAR EAST	N	30	30	30	30	30	30	30	*30*	*30*	*30*	*30*	*30*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
	NE	20	20	20	20	20	20	20	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	30	30	30	20	20
	E	15	15	20	20	20	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
EUROPE	SE	15	15	15	20	20	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
	S	15	15	15	15	15	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
	SW	10	10	10	10	10	15	15	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
	W	10	10	10	10	10	15	15	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
	NW	20	20	20	20	20	20	20	*20*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	30	30	30	20	20
S. AFRICA		15	15	15	20	20	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
S. AMERICA		15	15	15	15	15	15	15	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	15	15	15	15	15
ANTARCTICA		15	15	15	15	15	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
NEW ZEALAND		10	10	10	10	10	15	15	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	15	15	15	15	15
OCEANIA AUSTRALIA		10	10	10	10	10	15	15	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	15	15	15	15	15
JAPAN		20	20	20	20	20	20	20	*20*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	30	30	30	20	20

EASTERN USA

	EST	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00
ASIA FAR EAST	N	30	30	30	30	30	30	30	*30*	*30*	*30*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20	20	20
	NE	20	20	20	30	30	30	30	*30*	*30*	*40*	*40*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	30	30	30	20	20
	E	15	15	20	20	20	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
EUROPE	SE	15	15	15	20	20	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
	S	15	15	15	15	20	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
	SW	10	10	10	15	15	15	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
	W	10	10	10	15	15	15	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
	NW	20	20	20	20	20	20	20	*20*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	30	30	30	20	20
S. AFRICA		15	15	15	20	20	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
CARIBBEAN S. AMERICA		15	15	15	20	20	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
ANTARCTICA		15	15	15	15	20	20	20	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	20	20	20	20	20
NEW ZEALAND		10	10	15	15	15	15	15	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	15	15	15	15	15
OCEANIA AUSTRALIA		10	10	15	15	15	15	15	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	15	15	15	15	15
JAPAN		20	20	20	20	20	20	20	*20*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	*30*	30	30	30	20	20

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides the MUF during "normal" hours.

*Look at next **higher** band for possible openings.

ALPHA DELTA Tech Notes

ALPHA DELTA ANTENNA and AC LINE PROTECTORS — the inside story

- **Who Needs Them**
- **Do They Really Work**
- **Why Are There Several Different Models**

Who Needs Them

Lightning is the most common cause of component damage. However, we occasionally run into those who say "I've never been hit by lightning" or "I live on the West Coast and we don't have much lightning." Don't be fooled. There are demons lurking everywhere from your AC line to antenna that can damage your gear. Before exposing those, let's look at data about thunderstorms.

On average, the number of annual days with thunderstorms per area are approximately: West Coast, 5; Southwest, 20 to 40; Texas, 40 to 70; Midwest, 40 to 50; East Coast, 30 to 50; South, 50 to 70; and Florida, up to 100! Really, no matter where you live, you should be aware and protected from the potential for lightning-induced damage.

Now, what about what you can't see that *does* damage equipment? Dry desert winds in the Southwest and West Coast, wind driven snow and summer cloud buildup are all generators of enormous amounts of static electricity. Static-induced voltages from any one of these conditions can build up levels of 3 kV or more! If you've ever had the occasion to watch the static discharge jumping from the end of a long wire hanging near a chassis, you'll know what we mean.

What's worse, this type of damage is not always catastrophic. Semiconductors can suffer junction damage and will degrade over a period of weeks or months, causing subtle system problems and a gradual loss of sensitivity.

In the case of AC line protection, semiconductors are known to be damaged by transients caused by AC motors starting and switches, surges from power company "brown-outs" and poor regulation and even the effects of fluoresent lighting. If you have had the chance to see a graphic printout from an AC wall socket analyzer, you wouldn't plug *anything* in again that was unprotected.

So who needs Alpha Delta? Everyone. Regardless of season or geographic location.

Do They Really Work

First, let's settle one issue. Most storm damage comes from either voltage *induced* into the antenna from a near-hit lightning strike (as much as a mile away) or static buildup. No manufacturer claims their device will protect you from a direct lightning hit. That's because there is no standard by which to describe one. Some hits can generate currents of over 100,000 amperes. These might even destroy a house! Others are in the range of hundreds of amperes and may be satisfactorily by-passed to ground through a lightning protector.

Since the chances for damage from induced (non-direct hit) sources are several thousand times greater than direct hits, an effective protector has a definite place in a communications system.

Alpha Delta Transi-Trap™ ceramic gas tube protectors *do* provide effective protection because they were designed and tested to be used with the most sensitive semiconductors. They do this because they fire fast enough, (less than 100 nanoseconds), and at a low enough level to effectively by-pass the typical range of induced currents and voltages. Standard air-gap devices cannot reach this performance level due to variations in atmospheric conditions that will effect conduction of the static charge to ground.

In addition, Transi-Trap™ protectors are the only devices in the industry employing a combination of "fail-safe" isolated ground design and a field replaceable ARC-PLUG™ cartridge. *Isolated ground prevents the ARC discharge from flowing to the* equipment chassis via the coax shield. "Fail-safe" means the ARC-PLUG cartridge is designed to fail "shorted" instead of "open" in the event of a heavy discharge in excess of its rating. In this event, the equipment is still protected until the cartridge is replaced. Replacement is indicated by a "dead" receiver and high VSWR during tune-up.

Competitve air-gap devices suffer electrode disintegration and fail "open." You will lose your protection and you don't even know it! One competitive gas tube device is designed to melt its solder connections and fail "open" in the event of heavy current flow. The protection is gone, the element is non-replaceable and you still don't know it!

Transi-Trap™ protectors have been thoroughly tested by independent government and military test labs, and have been ordered for use around the world in a number of government and *military programs. An Avionics user recently reported* that since installing Transi-Trap™ devices, there has been no loss of communications due to induced transients. A leading designer of quality HF and VHF antennas, Butternut Electronics, suggests the use of Transi-Trap protectors in their literature.

A major computer manufacturer has selected MACC Master AC Control Consoles to protect their own systems from AC line transient related damage. This was done after extensive testing of all devices presently available.

Why Are There Several Different Models

We offer a choice of models to provide the most effective cost/power/frequency/connector combination.

STEP #1: Select your power range. The 200-watt models are the most sensitive to transient pulses and are the best choice for *receivers* and *transceivers*. The 2 kW models are designed for overall station protection and for linear amplifiers.

STEP #2: Select your frequency range. The UHF "T" connector models (LT, HT) offer low insertion loss protection through 148 MHz. The lowest-loss devices are the R-T and HV (typically 0.1 dB at 500 MHz) with UHF-type connectors. The R-T and HV models utilizing type "N" or "BNC" connectors offer even less loss through 1000 MHz! They are perfect for cellular radio and STL operation in the 800 and 900 MHz ranges.

Models available are:

Model LT:	UHF "T" type, 200 W, through 148 MHz	19.95
Model HT:	UHF "T" type, 2 kW, through 148 MHz	24.95
Model R-T:	UHF connectors, 200 W, through 500 MHz	29.95
Model HV:	UHF connectors, 2 kW, through 500 MHz	32.95
Model R-T/N:	N connectors, 200 W, through 1000 MHz	32.95
Model HV/N:	N connectors, 2 kW, through 1000 MHz	35.95

(BNC connectors also available)

The surge protected MACC models are: Model MACC - 8 outlets, and master switch control 79.95. MACC-4, same as above but with 4 outlets 59.95. ACTT - wall socket direct plug-in with 2 outlets 29.95.

Alpha Delta Transi-Trap antenna line protectors and MACC Master AC Control Consoles provide more than near-hit lightning protection. They will give you protection to cover all forms of static and transient surges from your antenna to your power line — at an attractive price.

Available from your local Alpha Delta dealer or direct plus shipping $2 Transi-Traps™, $4 MACC.

ALPHA DELTA COMMUNICATIONS, INC.

P.O. Box 571, Centerville, Ohio 45459 • (513) 435-4772

AA

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WE HAVE QUALITY PARTS, DISCOUNT PRICES AND *FAST* SHIPPING!

TRANSFORMERS

120 volt primaries

5.6 VOLTS @ 750 MA	$3.00
6 VOLTS @ 150 MA	$1.25
12 VCT @ 200 MA	$2.00
18 V. @ 650 MA	$3.50
18 VOLTS @ 1 AMP	$4.50
24 VOLTS @ 250 MA	$2.50
24 VCT @ 1 AMP	$4.50

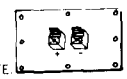
TRANSFORMER WALL

ALL ARE 115 VAC PLUG IN

4 VDC @ 70 MA	$2.00
6 VDC @ 500 MA	$5.00
9 VAC @ 1 AMP	$3.00
12.5 VAC @ 265 MA	$2.50
16.5 VAC @ 10 VA	$3.50
17 VAC @ 500 MA	$4.00

SPRING LEVER TERMINALS

TWO COLOR CODED TERMINALS ON A STURDY 2 3/4" - 3 3/4" BAKELITE PLATE. GREAT FOR SPEAKER ENCLOSURES OR POWER SUPPLIES.



$1.00 EACH 10 FOR $9.00

RS-232 EXTENSION

9 LINE CONNECTED LINES 1 THROUGH 8 & 20. DB25 MALE TO FEMALE. 10 FEET SHIELDED.

$11.00 EACH

MULTI-SWITCHES

3 STATION NON-INTERLOCKING

3 - 2PDT SWITCHES. EACH OPERATES INDEPENDENTLY. 1¾" BETWEEN MOUNTING CENTERS.

$1.75 EACH

5 STATION INTERLOCKING

MADE BY ALPS. 3 - 2PDT AND 2 - 6PDT SWITCHES ON FULLY INTERLOCKING ASSEMBLY. 3¼" BETWEEN MOUNTING CENTERS.

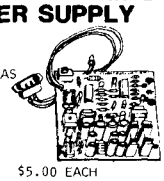
$2.50 EACH

5 STATION NON-INTERLOCKING

SAME AS ABOVE, EXCEPT EACH SWITCH OPERATES INDEPENDENTLY.

$2.50 EACH

TI SWITCHING POWER SUPPLY



TI # 1053214-2
COMPACT, WELL-REGULATED SWITCHING POWER SUPPLY DESIGNED TO POWER TEXAS INSTRUMENTS COMPUTER EQUIPMENT.
INPUT: 14VAC - 25.1VAC AT 1A
OUTPUT: + 12VDC AT 350MA
+ 5VDC AT 1.2A
- 5VDC AT 200MA
SIZE: 4 3/4" X 4 1/4" X 1 1/4"

$5.00 EACH

MIKE CONNECTOR

5 CONDUCTOR IN-LINE PLUG AND CHASSIS MOUNT JACK. TWIST LOCK STYLE, SAME AS SWITCHCRAFT 12CL5M.

$2.50 PER SET

METER 0 - 15 V.D.C.

THIS 2-1/4" SQUARE METER MEASURES 0-15 VDC.

$4.50 EACH

SUB-MINIATURE D TYPE CONNECTOR

SOLDER TYPE SUB-MINIATURE CONNECTORS USED FOR COMPUTER HOOK UPS.

DB-15 PLUG	$2.75
DB-15 SOCKET	$4.00
DB-15 HOOD	$1.50
DB-25 PLUG	$2.75
DB-25 SOCKET	$3.50
DB-25 HOOD	$1.25

"PARALLEL" PRINTER CONNECTOR

SOLDER STYLE 36 PIN MALE USED ON "PARALLEL" DATA CABLES.

$5.50 EACH

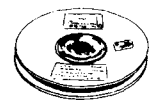
I.D.C. MALE

SAME AS ABOVE.

WILL PRESS FIT ON STANDARD RIBBON CABLE.

$8.00 EACH

7 CONDUCTOR RIBBON CABLE



SPECTRA-STRIP RED MARKER STRIP. 28 GA STRANDED WIRE.

$5.00 PER ROLL (100 FT.)

2K 10 TURN

MULTI-TURN POT

SPECTROL #MOD 534-7161

$5.00 EACH

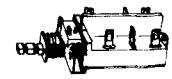
ROTARY SWITCH

1 POLE 6 POSITION

1¼" DIA x 1½" HIGH

75¢ EACH
10 for $6.00

PUSHBUTTON POWER SWITCH



DOUBLE POLE POWER SWITCH PUSH-ON, PUSH-OFF.

$1.00 EACH

SWITCHES

MINI-PUSH BUTTON

S.P.S.T. MOMENTARY NORMALLY OPEN 1/4" BUSHING

35¢ EACH
10 FOR $3.25
100 FOR $30.00

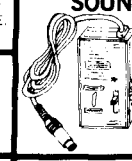
SPECIFY COLOR:
RED, BLACK, WHITE, YELLOW.

REVERBERATION UNIT

$7.50 EACH

ACCUTRONICS COIL SPRING TYPE UNITS. USED IN ELECTRONIC ORGANS TO PROVIDE ACOUSTIC DELAY SOUND EFFECTS. INPUT IMPEDANCE 8 OHMS, OUTPUT IMPEDANCE 2250 OHMS. 4½" x 16¾" x 1⅝".

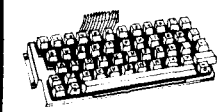
SOUND AND VIDEO MODULATOR FOR T.I. COMPUTER



T.I. # UM1381-1. DESIGNED FOR USE WITH T.I. COMPUTERS. CAN BE USED WITH VIDEO SOURCES. BUILT-IN A/B SWITCH. CHANNEL 3 OR 4 SELECTION SWITCH. OPERATES ON 12 VDC. HOOK UP DIAGRAM INCLUDED.

$10.00 EACH

48 KEY ASSEMBLY FOR T.I. COMPUTER



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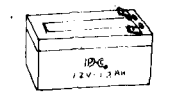

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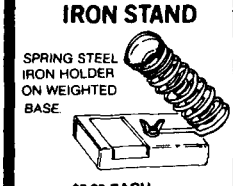

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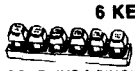

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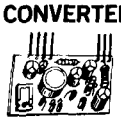

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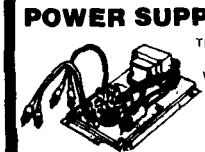

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100 FOR $80.00

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VHF/UHF WORLD

Joe Reisert W1JR

keeping VHF/UHFers up-to-date

I'm often asked questions such as: "How do I know what's the latest VHF/UHF technique? Where can I meet other VHF/UHF'ers? How can I keep up to date on important VHF/UHF happenings?" The answers to questions like these are largely a function of interests and the bands used; and thus can vary considerably.

Because these questions are so frequently asked, I decided to answer them in this month's column. I'll try to cover as many areas as possible, as objectively as I can. If I neglect to mention a valuable VHF/UHF resource with which you're familiar, please let me know so we can share it with others in a later column.

periodicals

Probably the most popular source of information for VHF/UHF'ers is contained in the monthly Amateur Radio magazines (**table 1**).

ham radio has always been a reliable source of information on VHF/UHF design and techniques. Since January, 1984, this column has appeared monthly. In addition to various articles on VHF/UHF subjects (see Cumulative Index, December, 1984, page 128), the annual antenna issue (May), the annual VHF/UHF issue (which first appeared in July, 1984), and the annual receiver issue (November) are of particular interest to VHF/UHF'ers.

CQ has recently added a VHF/UHF column. It also features articles on VHF/UHF techniques and equipment. In addition it has announced that it will resume its VHF contesting program with a VHF WPX contest in July, 1985.

QST also publishes articles of interest to VHF/UHF'ers. The monthly columns "The World Above 50 MHz" by Bill Tynan, W3XO, and "The New Frontier" by Bob Atkins, KA1GT, cover current VHF/UHF standings and records and reports on VHF/UHF activity. ARRL-sponsored VHF/UHF, and EME contest results are also published regularly.

73 has no formal VHF/UHF column but publishes articles featuring VHF, UHF, and microwave techniques.

Several periodicals published outside the United States may also be of interest to stateside VHF/UHF'ers. The most notable are *CQ-DL*, *CQ Ham Radio*, *Ham Journal*, and *Radio Communication* (see **table 2**).

CQ-DL, the official journal of the DARC (Deutscher Amateur Radio Club) of West Germany, is written entirely in German. Like *ham radio* and *QST*, it features a monthly VHF/UHF column as well as articles of interest to VHF/UHF'ers.

table 1. Major Amateur Radio periodicals published in the United States.

ham radio, Communications Technology, Inc., Greenville, New Hampshire 03048. Issued monthly. One-year subscription: $19.95 (U.S.A.).

CQ, CQ Publishing Company, 76 North Broadway, Hicksville, New York 11801. Issued monthly. One-year subscription: $16.00 (U.S.A.).

QST, ARRL, 225 Main Street, Newington, Connecticut 06111. Issued monthly. Annual membership in ARRL: $25.00 ([U.S.A.] includes subscription to QST).

73, 73 Subscription Department, Box 931, Farmingdale, New York 11737. Issued monthly. One-year subscription: $25.00 (U.S.A.).

CQ Ham Radio is the major monthly publication in Japan. Written in Japanese, it usually runs over 500 pages per issue. *Ham Journal*, also in Japanese, is a smaller, quarterly publication issued by the same publisher. Each issue of *Ham Journal* is based on a central theme. For instance, the Spring, 1984, issue was devoted almost entirely to EME.

Radio Communication ("*Radcom*") is the official journal of the RSGB (Radio Society of Great Britain). Like *QST*, it features articles on VHF/UHF and two VHF/UHF columns, "4-2-70" (70, 144, and 430 MHz) by Ken Willis, G8VR, and "Microwaves" by Mike Dixon, G3PFR. It is interesting to note

that British VHF/UHF'ers appear to have different interests than their American counterparts. Reading "*Rad Com*," the American reader senses a greater interest in portable operation and a large population of users on microwave frequencies such as 23, 13, and 3 cm. Unlike typical American designs, British designs tend to emphasize inexpensive or particularly clever design techniques.

professional periodicals

Several professional periodicals may also be of interest to VHF/UHF'ers (see **table 3**). In particular, they are the *IEEE Microwave Theory and Techniques (MTT)*,* the *IEEE Transactions on Antennas and Propagation (PGAP)*, *Microwave Journal*, *Microwaves & RF*, *Microwave Systems News*, and *RF Design*.

IEEE's *PGAP* and *MTT* are highly mathematical in nature but usually are devoted to the latest state-of-the-art developments in their respective fields of antennas, propagation, and microwaves. Only members of the IEEE may subscribe.

Microwave Journal, *Microwaves & RF*, *Microwave Systems News*, and *RF Design* are controlled-circulation publications available free of cost to "qualified" industry professionals and by subscription to "non-qualified" persons. These magazines specialize in reporting on the latest design techniques and equipment, with generous amounts of space devoted to advertisements and product reviews.

special interest publications

So far we've been talking mainly about magazines. There is, however, a substantial number of newsletters and small journals that are specifically written for VHF/UHF'ers. These are generally either "open distribution" publications or society or club publications.

The primary "general distribution" types are *VHF+ Trading Post*, *VHF/UHF and Above Information Exchange*, *2-meter EME Bulletin*, *220 Notes*, *432 and Above EME News*, *VHF/UHF Newsletter*, *DUBUS*, *VHF Communications*, *Amateur Television Magazine*, and *ORBIT* (see **table 4**).

VHF+ Trading Post is a new monthly newsletter that specializes in news and advertisements of interest to the VHF/UHF'er. *VHF/UHF and Above Information Exchange*, another new publication, with articles on VHF, UHF, and EME, as well as VHF/UHF'er comments and station descriptions. It also features K2UYH's "*432 and Above EME News*." The *2-Meter EME Bulletin* spotlights the latest happenings, news items, and station descriptions of interest to 2-meter EME'ers. All three publications stepped in to fill the gap when "*The Lunar Letter*" ceased publication.

220 Notes is dedicated to coverage of weak signal and FM/FM repeater activity on the 220-225 MHz band. Recent issues featured detailed background material on the Land Mobile industry's attempt to remove this band from the Amateur Radio service. *432 and Above EME News*, compiled by Allen Katz, K2UYH, features 70, 23, and 13-cm EME station reports, as well as some technical material and monthly EME schedules. A low-budget operation published mainly for the active EME'er on 70 cm and above, *432 and Above* cannot handle any more subscribers; it is, however, republished in the next available issue of *VHF/UHF and Above Information Exchange*.

The *RSGB VHF/UHF Newsletter* by David Butler, G4ASR, has just become available to readers outside of Europe. While it specializes in reporting on upcoming VHF and UHF activities in Europe, it also provides good material on meteor scatter, EME and new VHF and UHF techniques. *DUBUS* is a West German publication written mostly in English, but directed to European readers. *DUBUS* features information on stations, activities, and design for VHF/UHF operation.

VHF Communications is the English-language version of the German UKW Technik. Published quarterly, it features full-length articles on VHF, UHF, and microwave equipment design.

Amateur Television Magazine specializes in slow scan, fast scan, and satellite TV. It offers articles on equipment construction and operating techniques, and advertisements of interest to the video-oriented Amateur.

ORBIT, the journal of the Radio Amateur space program, is the official publication of AMSAT (Amateur Sat-

table 2. Major Amateur Radio periodicals published outside the United States (contact publishers for U.S. subscription rates).

CQ-DL, Published by the German Amateur Radio Club (DARC), Postfach 1155, 3507 Baunatal 1, West Germany. Issued monthly.

CQ Ham Radio, CQ Publishing Company Ltd., 14-2 Sugamo 1-Chome, Toshima-Ku, Tokyo 170, Japan. Issued monthly.

Ham Journal, CQ Publishing Company, Ltd., 14-2 Sugamo 1- Chome, Toshima-Ku, Tokyo 170, Japan. Issued quarterly.

Radio Communication, RSGB Headquarters, Alma House, Cranborne Road, Potters Bar, Hertsfordshire, EN6 3JW, England. Issued monthly.

table 3. Major professional publications of interest to VHF/UHF'ers.

IEEE MTT, IEEE Service Center, 445 Hoes Road, Piscataway, New Jersey 08854. Issued monthly. IEEE membership required. Contact publisher for rates.

IEEE PGAP, IEEE Service Center, 445 Hoes Road, Piscataway, New Jersey 08854. Issued monthly. IEEE membership required. Contact publisher for rates.

Microwave Journal, Horizon House, 610 Washington Street, Dedham, Massachusetts 02026. Issued monthly. One-year subscription: $36.00.

Microwaves and RF, Hayden Publishing Company, Box 1419, Riverton, New Jersey 08077. Issued monthly. One-year subscription: $30.00.

Microwave Systems News, E.W. Communications, Inc., Box 50249, Palo Alto, California 94303-0249. Issued monthly. One-year subscription: $35.00.

RF Design, Cardiff Publishing Company, 1 East First Street, Duluth, Minnesota 55802. Issued bi-monthly. One-year subscription: $15.00.

*Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, New York 10017.

table 4. Major VHF and UHF newsletters and publications.

VHF+ Trading Post, c/o Jack Parker, KCØW, P.O. Box 11023, Reno, Nevada 89510. Issued monthly. One-year subscription: $5.00.

VHF/UHF and Above Information Exchange, c/o Rusty Landes, KAØHPK, P.O. Box 270, West Terre Haute, Indiana 47885. Issued monthly. One-year subscription: $15.00.

2-Meter EME Bulletin, c/o Gene Shea, KB7Q, 417 Stadhauer, Bozeman, Montana 59715. Issued monthly. One-year subscription: $12.00.

220 Notes, c/o Walt Altus, WD9GCR, 215 Villa Road, Steamwood, Illinois 60103. Six issues per year. One-year subscription: $5.00

432 and Above EME News, c/o Allen Katz, K2UYH, 326 Old Trenton Road, RD 4, Trenton, New Jersey 08691. Issued monthly. (See text).

VHF/UHF Newsletter, RSGB Headquarters, Alma House, Cranborne Road, Potters Bar, Hertsfordshire EN6 3JW, England. Issued monthly. Contact publisher for rates.

DUBUS, c/o Claus Neie, DL7QY, D-7181 Rudolfsberg 24, West Germany. Issued quarterly. Contact publisher for rates.

VHF Communications, c/o Terry D. Bitten, Jahnstrasse 14, Postfach 80, D-8523 Baiersdorf, West Germany. Issued quarterly. Contact publisher for rates.

Amateur Television Magazine, c/o QCD Publications Inc., P.O. Box H, Lowden, Iowa 52255. Issued monthly. One-year subscription: $10.00.

ellite Corporation). It features construction articles, equipment reviews, station descriptions, and the latest information on Amateur Radio satellites.

club newsletters

There are numerous club publications often available to nonmembers at a nominal cost. Those that come to mind are *Six Shooter*, The *Sidewinders on Two Bulletin*, *The Southeastern VHF Society and 70-cm Net Newsletter*, *Northeast VHF News*, *Texas VHF-FM Society News*, *The West Coast VHF'er*, *Radiosporting*, and *Cheese Bits* (see **table 5**).

Six Shooter, the official journal of SMIRK (Six Meter International Radio Klub), specializes in coverage of 6-meter activities. You can join SMIRK after contacting six members on 6 meters. SMIRK also sponsors awards and an annual contest.

The *Sidewinders on Two Bulletin* is the official newsletter of SWOT (Sidewinders on Two), which specializes in 2-meter activity. Members are admitted after contacting 2 SWOT members on 2 meters. SWOT also sponsors an annual contest and awards.

The *Southeastern VHF Society and 70-cm Net Newsletter* is a publication of the Southeastern 70-cm net. In addition to 70-cm news, it features items of general and technical interest to VHF/UHF'ers.

Northeast VHF News, sponsored by the Northeast VHF Association, carries news of interest to local, national, and international VHF/UHF'ers. *Texas VHF-FM Society News* specializes in FM and FM repeaters in the Texas area as well as meeting notes from the Texas VHF-FM Society.

The West Coast VHF'er concentrates on information of interest to the California VHF/UHF'er. *Radiosporting* is a new magazine which promises to focus on the art of Amateur contesting. The Mount Airy VHF Radio Club, Inc. Pack Rats' *Cheese Bits* is a club newsletter that includes product reviews, an activity calendar, a swap and shop column, and short technical articles.

Let us not forget those publications that while no longer available, are still an excellent source of information if you can borrow copies. The first ones that come to mind are *The VHFER* (K7AAD), *6 UP* (*73*), *220 MHz EME Newsletter* (K5FF), *Northern California 220 News* (WA6GYD), *432 Bulletin* (W6FZJ), and *The Lunar Letter* (KI7D).

Other short publications or newsletters while general in nature, often print information of interest to VHF/UHF'ers (see **table 6**). They are *The ARRL Letter*, *World Radio*, *QEX*, *Westlink Report* (formerly HR Report), *The W5YI Report*, *Gateway*, and *DX Bulletin*.

The *ARRL Letter* is primarily dedicated to keeping the Amateur informed of Amateur Radio news in general. As such, it provides up-to-date information in a timely fashion. *World Radio* based in Sacramento, California, is an Amateur Radio newspaper. It publishes articles of general interest to the Amateur and features several columns including ones on DX, antennas, the FCC, and OSCAR. *QEX*, the ARRL experimenters' exchange, is a monthly ARRL newsletter specializing in articles that may be too technical in nature for

table 5. VHF/UHF club and organization bulletins.

Six Shooter, c/o Ray Clark, K5ZMS, 7158 Stone Fence, San Antonio, Texas 78227. Issued quarterly, Annual membership dues $6.00, plus $3.00 for subscription.

The Sidewinders on Two Bulletin, c/o Harry Arsenault, K1PLR, 603 Powell Avenue, Erie, Pennsylvania 16505. Issued monthly, One-year subscription: $10.00.

Southeastern VHF Society and 70-cm Net Newsletter, c/o Charles Osborne, WD4MBK, 131 Saratoga Drive, Lawrenceville, Georgia 30245. Issued quarterly. One-year subscription: $5.00.

Northeast VHF News, c/o Lewis Collins, W1GXT, 10 Marshall Terrace, Wayland, Massachusetts 01778. Six issues per year. One-year subscription: $3.00.

TX VHF-FM Society, c/o Robert McWhorter, K5PFE, Box 461, Jasper, Texas 75951. Issued bi-monthly. One-year subscription: $6.00.

The West Coast VHFer, 560 West Yucca Street, Oxnard, California 93033. Issued monthly. One-year subscription: $10.00.

Radiosporting, c/o Yuri Blanarovich, VE3BMV, Box 65, Don Mills, Ontario, M3C 2R6, Canada. Issued monthly. $12.00 annual membership *plus* $16.00 for one-year subscription.

The Pack Rats' Cheese Bits, c/o Doc Cutler, K3GAS, 7815 New Second Street, Elkins Park, Pennsylvania 19117. Issued monthly. One-year subscription: $2.50.

table 6. Newsletters of a general nature that often cover news of interest to VHF/UHF'ers.

The ARRL Letter, c/o ARRL, 225 Main Street, Newington, Connecticut 06111. Issued bi-weekly. One-year subscription: $19.50. (ARRL members only).

QEX, c/o ARRL, 225 Main Street, Newington, Connecticut 06111. Issued monthly. One-year subscription: $6.00 (ARRL members only).

Westlink Report, c/o Poco Press, 11119 Allegheny Street, Sun Valley, California 91352. Issued bi-weekly. One-year subscription: $22.50.

The W5YI Report, Box 10101, Dallas, Texas 75207. Issued bi-weekly. One-year subscription: $24.00.

Gateway, c/o ARRL, 225 Main Street, Newington, Connecticut 06111. Issued bi-weekly. One-year subscription: $6.00 (ARRL members only).

World Radio, 2120 28th Street, Sacramento, California 95813. Issued monthly. One-year subscription: $10.00.

QST. Articles on experimental aspects of VHF/UHF are always welcome. Geoffrey Krauss, WA2GFP, writes a bi-monthly column for *QEX*.

The two major Amateur Radio bi-weekly newsletters are *The Westlink Report* (formerly *HR Report*) and *W5YI Report*. They primarily cover Amateur Radio news items, with emphasis on FCC matters, legislative problems, recent or upcoming events. VHF/UHF news is printed as it becomes available. *Gateway*, the latest ARRL publication, specializes in packet radio communications in a format similar to *QEX*. *Gateway* should be especially interesting to those people using packet radio for VHF meteor scatter.

DX Bulletins

Many DX bulletins are published regularly. These newsletters usually provide important propagation information as well as VHF/UHF reports (when received). This category includes *The DX Bulletin* (K1TN), *QRZ DX* (W5KNE), *LIDXA Bulletin* (W2IYX), and The *DX'ers Magazine* (W4BPD), among others. *The Northern California DX Foundation Newsletter* (N6ST) has contributed to at least two VHF/UHF DXpeditions.

catalogs and advertisements

Although advertisements and catalogs are intended to sell products, they can also provide useful information about the state-of-the-art, availability of components and similar subjects. Don't overlook advertisements as a source of helpful information. New product reports and reviews in periodicals and newsletters can also be useful.

Amateur reference materials

Numerous books and references useful to the VHF/UHF'er include but are not limited to *The ARRL 1985 Handbook for The Radio Amateur, Radio Handbook, VHF/UHF Manual, VHF Handbook for Radio Amateurs, The Radio Amateur's VHF Manual, VHF for the Radio Amateur, The UHF Compendium* (Parts 1 and 2), *The Satellite Experimenter's Handbook, ARRL Antenna Book, The Microwave Newsletter Technical Collection*, and *From Beverages Thru OSCAR — A Bibliography, with Addendum* (see **table 7**).

The ARRL 1985 Handbook for The Radio Amateur and Bill Orr's *Radio Handbook* each have several chapters devoted to VHF/UHF communications. The *VHF/UHF Manual* (RGSB), *VHF Handbook for Radio Amateurs, The Radio Amateur's VHF Manual*, and *VHF for the Radio Amateur* are entirely devoted to VHF/UHF and Microwaves, with information on antennas, receivers, transmitters, etc. The *Microwave Newsletter* may be out of print and only a few dozen copies of the *Bibliography* are still available from the source. Both include basic material useful to VHF/UHF'ers.

The *UHF Compendium* (Parts 1 and 2), a translation of a German publication, is a great source of information for designing receivers, antennas, and transmitters. Heavy emphasis is placed on practice and construction. *The Satellite Experimenter's Handbook* is a history of and guide to all of the Amateur Radio Satellites. It shows readers how to find the various satellites and recommends specific antennas, preamplifiers, and transmitters. The *ARRL Antenna Book* is an excellent reference for both HF and VHF. *The Microwave Newsletter Technical Collection* consists of edited extracts from the best UHF and microwave notes published in the RSGB *Microwave Newsletter* since 1980.

table 7. Recommended VHF, UHF, and Microwave references.

The ARRL 1985 Handbook for the Radio Amateur, ARRL, 225 Main Street, Newington, Connecticut 06111, $15.00.[1]

Radio Handbook, William I. Orr, W6SAI, $12.95.[1]

VHF/UHF Manual, Pat Jessop, G5JP. Published by the RSGB. $17.50.[1]

VHF Handbook for Radio Amateurs, Herb Brier, W9EGQ, and William I. Orr, W6SAI, $11.95.[1]

The Radio Amateur's VHF Manual, Edward P. Tilton, W1HDQ, ARRL, 225 Main Street, Newington, Connecticut 06111. (out of print)

VHF for the Radio Amateur, Frank C. Jones, W6AJF, CQ Publications, 76 North Broadway, Hicksville, New York 11801 (out of print).

The UHF Compendium, Parts 1 and 2, K. Weiner, DJ6HO, Editor (out of print).

The Satellite Experimenter's Handbook, Martin Davidoff, K2UBC, ARRL, 225 Main Street, Newington, Connecticut 06111. $10.00.[1]

The ARRL Antenna Book, 14th edition, Gerald L. Hall, K1TD, Editor, $8.00.[1]

The Microwave Newsletter Technical Collection, J. Gannaway, G3YGF, and S.J. Davies, G4KNZ. Published by the RSGB. $10.00.[1]

From Beverages Thru OSCAR — A Bibliography, (with Addendum). *Volume 1* (1945-1978) 620 pp, $29.95, *Volume 2*, (1979-1981) 144 pp, $9.95. Both volumes: $35.95. Contact author, Rich Rosen, K2RR, at *ham radio*.

Note 1. Available from Ham Radio's Bookstore, Greenville, New Hampshire 03048. *Add $3.50 for shipping and handling.*

table 8. Calling frequencies.

6 meters	50.110 MHz
2 meters	144.200 MHz
135 cm	220.100 MHz
70 cm	432.100 MHz
23 cm	1296.100 MHz
13 cm	2304.100 MHz

From Beverages thru OSCAR — A Bibliography is a unique reference book that lists, in chronological order, virtually every Amateur Radio article written in the last 30 or so years through 1981.* Over 36,000 articles appearing in the Amateur press (as well as in some professional publications) are included. As such, it is a good source for determining what resources are available, where and when they were published. All of these valuable references are a must for the library of any well-rounded, informed VHF/UHF'er.

nets

Nets are a valuable and timely source of information for those interested in VHF, UHF, and microwaves. Local and VHF/UHF club nets are quite common. SMIRK and SWOT sponsor numerous 6 and 2-meter nets; their members can direct you to nets in your local area.

There are several HF nets or "hangout" frequencies where VHF/UHF'ers can often be found. The 6-meter enthusiasts can often be found on 28.885 MHz when 10 and/or 6 meters is open. Much crossband and 6-meter DX was coordinated on this frequency when F2 propagation was common at the peak of solar cycle 21.

The CSVHF (Central States VHF Society) has a net on 3818 kHz, usually at 9:30 PM CST on Sunday evenings. VHF/UHF'ers, especially those in the central United States, often use this frequency at night — and especially during meteor showers — to exchange information and schedules.

14,345 kHz has long been used by Europeans as a VHF scheduling frequency. Every Saturday and Sunday the 70-cm EME net meets on 14,345 kHz at 1600 UTC. The 2-meter EME net follows at approximately 1700 UTC. These nets, although primarily devoted to EME, are a good source of information on important VHF/UHF happenings. Many VHF'ers are known to monitor (but don't necessarily check in) these nets to get the latest "scoop." The EME'ers and many VHF/UHF'ers also use OSCAR 10 as an intercom, and can often be heard on the downlink frequency of 145.950.

Other HF gatherings also take place. Of particular note is a large group of VHF'ers that seems to "hang out" on 160 meters where they swap stories or lies. I guess the 160-meter crowd has something in common with VHF/UHF'ers: *they also enjoy suffering with weak signals and noise*!

Don't forget the weekly *OSCAR* nets (see *QST* for frequencies, dates, and times). They are a good source of VHF/UHF as well as satellite information.

calling frequencies

Often the VHF or UHF frequencies are quiet because there are simply fewer VHF/UHF'ers than HF'ers. VHF/UHF propagation is also more restricted than HF. As a result, the VHF'ers have established "calling frequencies," where everyone can monitor, call CQ occasionally, or establish communications with someone else who monitors that same frequency. It is common courtesy to slide off the calling frequency after making contact so that someone else can use it.

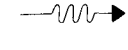
Monitoring calling frequencies can be a good way to find out who's active and what's happening (see **table 8**). The prime calling frequencies in the USA are 50.110, 144.2, 220.1, 432.1, and 1296.1 MHz. As previously mentioned, the OSCAR 10 downlink frequency of 145.950 MHz also serves as a gathering and calling frequency for VHF/UHF'ers.

activity

The Northeast VHF Association has introduced a popular system concentrating activity and thereby increasing the likelihood of meeting other interested VHF/UHF'ers. This system is built around "activity nights" and "activity hours," see **tables 9** and **10**. Basically, the system works this way. Sunday night is 6-meter activity night; Monday is 2 meters; Tuesday is 135 cm; Wednesday is 70 cm; Thursday is 23 cm. (Anyone for 13 cm on Fridays?) By concentrating on a single band each night, VHF/UHF'ers, especially those who operate multiple bands, are more likely to find other interested parties. These nights are a great source of information exchange. During VHF/UHF contests it may be difficult to catch all active stations, especially those that operate several bands. Again, a technique recently suggested by the Northeast VHF Society consists of concentrating afternoon contest activity by establishing specific activity hours. 135-cm activity starts at 2 PM, 70 cm at 3 PM, and 23 cm at 4 PM. For many years a similar system has been used in the mornings and evenings, with 2 meters at 7 AM/PM, 135 cm at 8 AM/PM, etc. When everyone adheres to this plan, there is less likelihood of missing other active stations. It's also a good way to just keep in touch.

contests, conferences and shows

Contests can be good sources of information exchange. The ARRL sponsors VHF, UHF, EME, and SPRINT (single band short duration contest) contests throughout the year. (I try to list all contests at the end of this column every month). So do SMIRK (in June) and SWOT (in July). The Europeans also have many contests, with the biggest being the International VHF Contest held on the first weekend of October.



*From Beverages Thru OSCAR — A Bibliography is in the process of being updated to include all published articles up to, and including, December, 1984.

Please send all reader inquiries directly.

table 9. Suggested VHF/UHF "activity nights."

6 meters	Sunday
2 meters	Monday
135 cm	Tuesday
70 cm	Wednesday
23 cm	Thursday
13 cm	Friday

table 10. Suggested "activity hours" during VHF/UHF contests.

2 meters	7AM	1PM	7PM
135 cm	8AM	2PM	8PM
70 cm	9AM	3PM	9PM
23 cm	10AM	4PM	10PM
13 cm	11AM	5PM	11PM

One excellent way to stay informed and meet with other interested VHF, UHF, and Microwave enthusiasts is to attend conferences. Often antenna and noise figure measurements are conducted; this can be an excellent way to see how your receiver, preamplifier, or converter and antenna stack up against others. At the same time, one can swap circuits and tips on improving performance, see firsthand the latest state-of-the-art tricks and devices.

The Dayton Hamvention is one of the first conferences held each year. Recently the Hamvention has sponsored a VHF/UHF program under the guidance of WA8ONQ and has now added noise figure and antenna measurements. The long-standing West Coast VHF Conference, held in California in early May, the Eastern VHF/UHF Conference, held in mid-May in New Hampshire, and the CSVHF Society Conference held the last weekend of July in the midwest, are totally dedicated to technical sessions on VHF/UHF and microwave techniques. All of these conferences sponsor antenna and noise figure measurements as well.

The Mid-Atlantic States Conference, held the first weekend in October in eastern Pennsylvania includes technical talks and a flea market. For those who travel abroad, Europeans have similar conferences in both Germany and England (contact the DARC or RSGB). A new conference dedicated solely to 1296 and 2304 MHz will be held in Colorado this September. Notes and handouts are frequently one of the highlights of these conferences. Recently the CSVHF Society began issuing a set of proceedings at their conference (contact KØDAS).

Finally, many area and ARRL conferences (especially the ARRL National) often feature VHF and UHF programs. An excellent source of information, these programs provide ample opportunity to meet and talk with experts in the field. As in the past, I will try to announce these conferences and the names of appropriate contact people at the end of each month's column.

awards programs

Awards programs generate activity and challenge VHF/UHF and microwave enthusiasts to improve their gear and operating techniques. The most common awards are the IARU WAC, the ARRL WAS, and the ARRL VUCC. Information on these awards can be obtained by sending an SASE to ARRL. The RSGB has members-only Microwave Transmitting Awards somewhat like the VUCC but specializing on the 23 cm and higher bands. Contact the RGSB for further details. The VUCC Award, which has done much to stimulate activity on the VHF/UHF bands, is based on contacts with different grid squares, a section of land included within a block measuring 2 degrees wide (longitude) by 1 degree high (latitude).[1] The WAS and VUCC standings boxes in "The World Above 50 MHz" in *QST* are an excellent way to discover who's active in your area.

conclusion

VHF and UHF'ers have a relatively poor track record when it comes to "Communicating." Exchange of information — especially in a timely way — has always been a problem. In this column therefore, I've tried to identify the principal sources of information for VHF/UHF'ers and HF'ers alike. I hope this material will provide readers with new sources of information; if you'll let me know of any important material I may have missed, I'll share it with *ham radio*'s readers in a later column.

reference

1. John Lindholm, W1XX, "VHF/UHF Century Club Awards," *QST*, January, 1983, page 49.

upcoming VHF/UHF events

March 21: *Optimum date for TE contacts.*

September 20-22: *I've just been informed by Don Hillard, WØPW, Box 563, Boulder, Colorado 80306, that he intends to sponsor a 1296 and 2304 MHz conference in Estes Park, Colorado. Drop Don an SASE for additional information on this gathering.*

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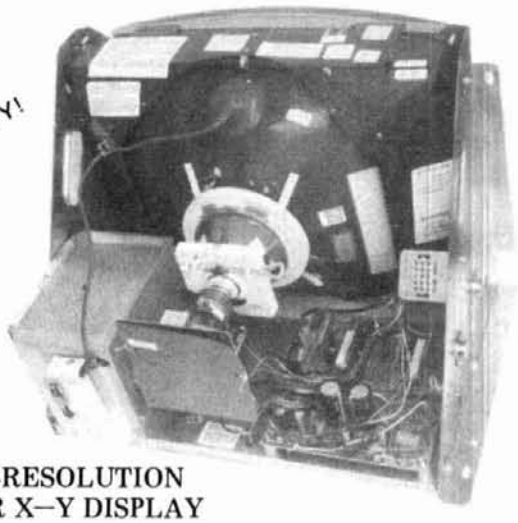

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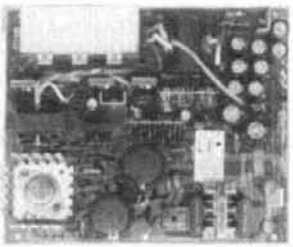

This regulated multi-voltage switching power supply board is made by KEPCO (their part no. MRM 174 KF) and is still in production (. . . regular price $124.95). It was originally part of the Zorba portable PC. The four outputs are as follows: & +5 VDC @ 5 A, +12 VDC @ 2.8 A, +12 VDC @ 2 A, and −12 VDC @ .5 A. The +12 VDC @ 2 A is very heavily filtered so it could be used on a glitch free monitor. The −12 VDC @ .5 A can be changed to −5 VDC just by changing the onboard 7912 regulator chip to a 7905. The board's lightweight and small size should make it perfect for many projects. All new and provided with a schematic. The input is jumper selectable 110/220. New, unused.
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Shpg. Wt. 2 Lbs. ea. SPL-471-33B ~~2/$90.00~~
$40.00 each 2/$75.00

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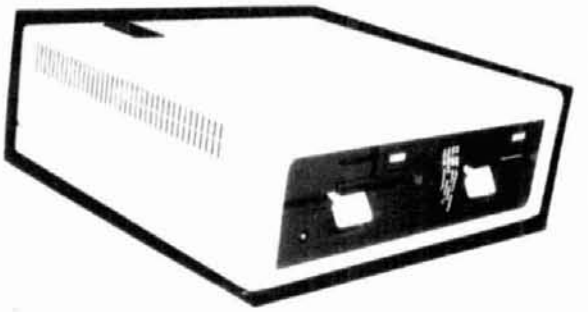

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RX 180 AB modified to run w/ the TI 99/4A $285.00

Disc drive cable for Radio Shack Model I $15.00 Disc drive cable for TI 99/4A $15.00

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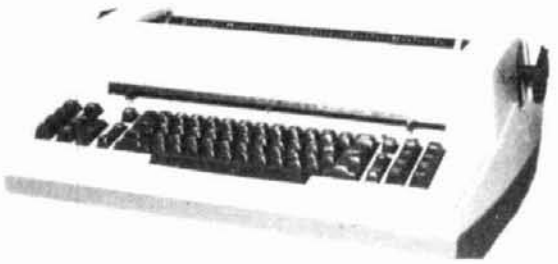

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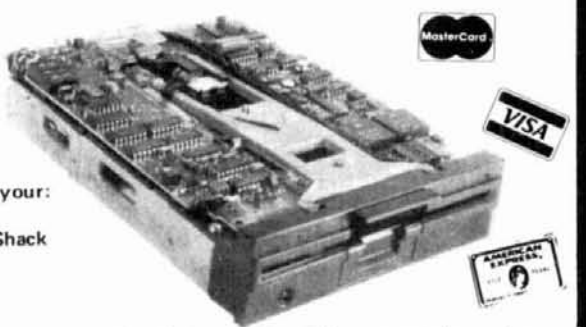

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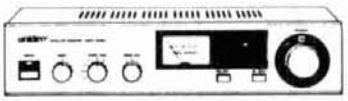
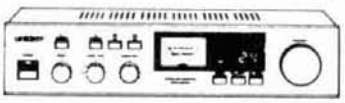
Vilson YM400 System $1242

)rake ESR 240 System $1542
)rake ESR 324 System $1392
.uxor Mark II System $1908
Maspro SRS System $1692
)excel 1300-01 System $1543
)excel 1200-01 System $1293
)excel 900-01 System $1178

Uniden UST 1000 Sys. $1322



Uniden UST 3000 Sys. $1472



Boman SR1500 System $1233
STS MBS-SR System $1512
M/A Com H1 System $2082
M/A Com T1 System $1982
Toki TR 110S System $1333
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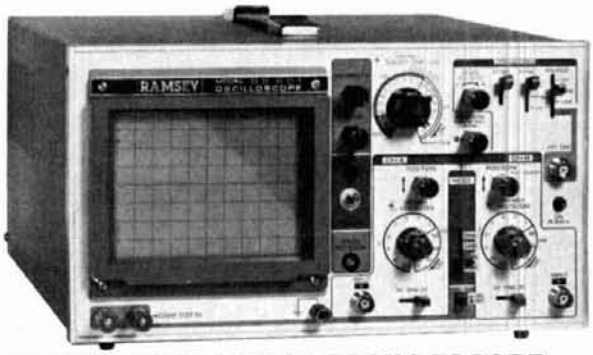

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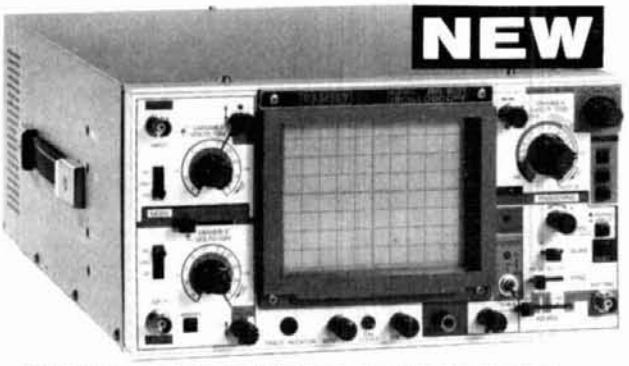

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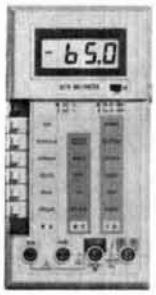

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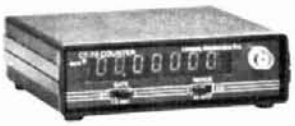

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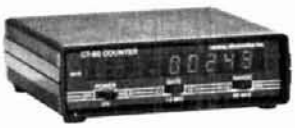
CT-70 kit $99.95
BP-4 nicad pack 8.95



CT-90 9 DIGIT 600 MHz COUNTER

The most versatile for less than $300. Features 3 selectable gate times • 9 digits • gate indicator • display hold • 25mV @ 150 MHz typical sensitivity • 10 MHz timebase for WWV calibration • 1 ppm accuracy

$149.95 wired includes AC adapter

CT-90 kit $129.95
OV-1 0.1 PPM oven timebase 59.95
BP-4 nicad pack 8.95

CT-125 9 DIGIT 1.2 GHz COUNTER

A 9 digit counter that will outperform units costing hundreds more. • gate indicator • 24mV @ 150 MHz typical sensitivity • 9 digit display • 1 ppm accuracy • display hold • dual inputs with preamps

$169.95 wired includes AC adapter

BP-4 nicad pack 8.95

CT-50 8 DIGIT 600 MHz COUNTER

A versatile lab bench counter with optional receive frequency adapter, which turns the CT-50 into a digital readout for most any receiver • 25 mV @ 150 MHz typical sensitivity • 8 digit display • 1 ppm accuracy

$169.95 wired

CT-50 kit $139.95
RA-1 receiver adapter kit 14.95

DM-700 DIGITAL MULTIMETER

Professional quality at a hobbyist price. Features include 26 different ranges and 5 functions • 3½ digit, ½ inch LED display • automatic decimal placement • automatic polarity

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DM-700 kit $99.95
MP-1 probe set 4.95

PS-2 AUDIO MULTIPLIER

The PS-2 is handy for high resolution audio resolution measurements, multiplies UP in frequency • great for PL tone measurements • multiplies by 10 or 100 • 0.01 Hz resolution & built-in signal preamp/conditioner

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PS-2 kit $39.95

PR-2 COUNTER PREAMP

The PR-2 is ideal for measuring weak signals from 10 to 1,000 MHz • flat 25 db gain • BNC connectors • great for shifting RF • ideal receiver/TV preamp

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PR-2 kit $34.95

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new ICOM headquarters

ICOM America's new 40,000 square foot corporate headquarters/sales and service center in Bellevue, Washington, has been completed. Growth in its expanding line of Amateur Radio equipment had caused ICOM America to outgrow its prior facility; the new building allows for expanded service and warehouse areas as well as areas designated for future engineering and manufacturing divisions.

For information on ICOM products, contact ICOM America, Inc. at its new address: 2380-116 Avenue NE, Bellevue, Washington 98004.

Circle #301 on Reader Service Card.

handheld analog/digital multimeters

John Fluke Manufacturing has introduced two new heavy-duty analog/digital multimeters — the Fluke 25 and the Fluke 27 — designed specifically for industrial use. The new Fluke 20 Series combines the accuracy of a digital meter with the dynamic measurement capabilities of an analog meter. Built to endure environmental and electrical abuse, these sealed meters can withstand drops, shock, vibration, contaminants, moisture, and other harsh conditions.

Both are available in either safety yellow or dark charcoal gray. Their liquid crystal display works even at extreme temperatures; operation is guaranteed from – 15 degrees C to 55 degrees C and to – 40 degrees C for 20 minutes. Typical continuous operation is from – 20 degrees C to 60 degrees C.

The Fluke 25 is priced at $229; the Fluke 27 at $259.

For complete details, contact John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, Washington 98206.

automatic antenna tuner

The Heath Company has expanded its Amateur Radio line to include the new SA-2500 Auto-Tune Antenna Tuner. The SA-2500 features an efficient, continuously variable roller inductor that can be preset for 18 different frequencies.

The SA-2500 permits the user to preset high and low frequencies on each of the nine bands from 160 to 10 meters. In the Auto mode this tuner sets the roller inductor to the preselected value and automatically adjusts the preset for a proper match. A remote capability allows selected frequencies to be automatically tuned to the proper SWR using only transmitter band switches, provided the transmitter is equipped for remote operation.

Manual tuning is simplified with three front panel lever switches and dual wattmeters. The wattmeters read forward and reflected average power and SWR in two ranges. An auto-range circuit automatically switches the wattmeters to the appropriate range.

The SA-2500 effectively tunes and matches unbalanced feed lines and single-wire antennas at the full legal power limit of a station. The SA-2500-1 4:1 Balun Accessory can be added for use with balanced ladder line antennas. A front panel coax switch allows the user to select easily from three different, permanently connected antennas and bypass.

Heath's Auto-Tune Antenna Tuner installs directly into the transmission line. The internal SWR wattmeter bridge will measure power on all frequencies between 1.8 and 30 MHz, 200/2000 watts in the forward direction and 50/500 watts reflected. SWR readings on the reflected meter provide direct readings from 1:1 to 3:1.

For more information and a free catalog, contact Heath Company, Department 150-395, Benton Harbor, Michigan 49022.

Circle #303 on Reader Service Card.

"dishpositioner"

Electroaids Inc. has announced the introduction of its Electro-Scan '85 "dishpositioner." The reliability of the new Electro-Scan '85 has been increased by the inclusion of minor improvements in the state-of-the-art circuitry. The exterior of the control box has also been redesigned for greater attractiveness and a more contemporary appearance.

The Electro-Scan '85 uses an analog micro system and features a dial control that shows dish location by actual satellite name. The "dishpositioner" uses a 36-volt DC motor drive for safety, and offers precise positioning along with a lock and key on the control box for owner control.

Information on the unit is available from Electro-Com, Suite 112, 8459 N. Main Street, Dayton, Ohio 45415.

Circle #302 on Reader Service Card.

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(See "Publisher's Log," April, 1984, page 6, for details.)

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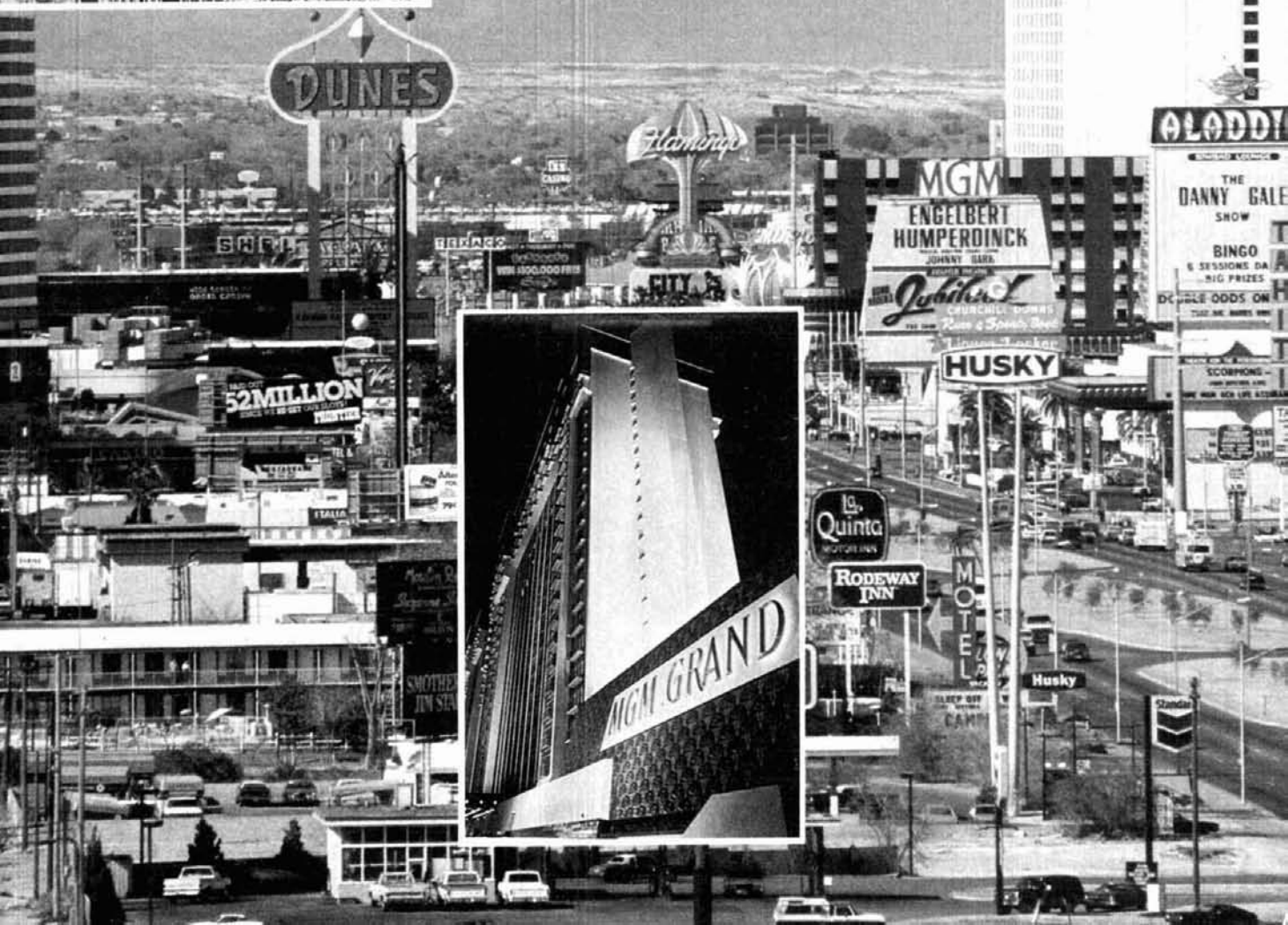

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DET-3	SSB DET. LM 1496 SSB Detector (Needs OSC-1 or OSC-4)	$9.95
DET-4	DETECTOR CW/SSB using a dual gate FET transistor	$4.95
IFA-1	IF AMP. CA 3028 30 DB Gain, Optional AGC (455 KHZ or 9-11 MHZ)	$6.95
FLS-9	SSB FILTER 9 MHZ/2.1 KHZ BW with USB XAL for OSC-1	$49.95
IFA-2	IF AMP. CA 3028 30 DB Gain 1-100 MHZ Optional AGC	$6.95
MBA-1	FREQ. MULT. Tuned Output Buffer-Mult.-Amplifier To 250 MHZ	$5.95
OSC-1	CRYSTAL OSC. 100 KHZ — 20 MHZ Not Tuned	$3.95
OSC-2	CRYSTAL OSC. Ov 18-200 MHZ Tuned Output	$4.95
PSV-1	POWER SUPPLY LM 723 With Pass Transistor, 3 amps max	$7.95
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HR

Tell 'em you saw it in HAM RADIO!

More Details? CHECK—OFF Page 160

short circuits

solar power

In the article, "Complete Solar Power for your ham station," by NH6N, (December, 1984, page 22, the note in **fig. 6** should be changed to read: "Adjust P-1 to have comparator go low at 0.5 A or greater as desired."

VIC-20-/ASR-33 printer

In the September, 1984 issue a line of coding was inadvertently omitted from the program listing in W2QLI's ham note, "VIC-20 printer" (page 88). **210 GET B$** should be inserted between lines 200 and 220. Other than that, both **figs. 1A** and **1B** are correct and the circuit/software combination should work.

The following additional information provided by the author should also aid in joining micros to teletype machines:

"One does not have to use the 9-pin terminal strip under the call box on the ASR-33. Socket No. 2 at the end of the call box on the ASR-33 has 15 pins (see **fig. 1**) and is easy to get at. These pins are connected to the terminal strip. Radio Shack sells a 12-pin plug. All one has to do is cut the top off the plug so that it will fit the 15-pin socket.

"I believe the interface will work with the Commodore 64 or any other micro, that has the necessary outputs and can accept the listing. (It should also be possible to use the ASR-35 and ASR-43.)

"I ran a big Centronics 101A printer using the **fig. 1B** interface. It required 2400 baud. (The ASR-33 provides 110 baud, ASCII.) I have other software for the VIC-20-to-ASR-33 such as "screen dump," "save on tape," and "run to the ASR-33."

The nice feature of this VIC-20-to-ASR-33 is that it works both ways. Type on the VIC-20, and it prints on the paper of the ASR-33; type on the ASR-33 keyboard, and it appears on both the screen and paper."

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Building a current *ham radio* project? Call the Short Circuit Hotline any time between 9 AM and Noon, or 1 to 3 PM – Eastern time – *before* you begin construction. We'll let you know of any changes or corrections that should be made to the article describing your project.

(See "Publisher's Log," April, 1984, page 6, for details.)

603-878-1441

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2K28	200.00	4624	310.00	7854	130.00
3-500Z	102.00	4657	84.00	ML7855KAL	125.00
3-1000Z/8164	400.00	4662	100.00	7984	14.95
3B28/866A	9.50	4665	500.00	8072	84.00
3CX400U7/8961	255.00	4687	P.O.R.	8106	5.00
3CX1000A7/8283	526.00	5675	42.00	8117A	225.00
3CX3000F1/8239	567.00	5721	250.00	8121	110.00
3CW30000H7	1700.00	5768	125.00	8122	110.00
3X2500A3	473.00	5819	119.00	8134	470.00
3X3000F1	567.00	5836	232.50	8156	12.00
4-65A/8165	69.00	5837	232.50	8233	60.00
4-125A/4D21	79.00	5861	140.00	8236	35.00
4-250A/5D22	98.00	5867A	185.00	8295/PL172	500.00
4-400A/8438	98.00	5868/AX9902	270.00	8458	35.00
4-400B/7527	110.00	5876/A	42.00	8462	130.00
4-400C/6775	110.00	5881/6L6	8.00	8505A	95.00
4-1000A/8166	444.00	5893	60.00	8533W	136.00
4CX250B/7203	54.00	5894/A	54.00	8560/A	75.00
4CX250FG/8621	75.00	5894B/8737	54.00	8560AS	100.00
4CX250K/8245	125.00	5946	395.00	8608	38.00
4CX250R/7580W	90.00	6083/AZ9909	95.00	8624	100.00
4CX300A/8167	170.00	6146/6146A	8.50	8637	70.00
4CX350A/8321	110.00	6146B/8298	10.50	8643	83.00
4CX350F/8322	115.00	6146W/7212	17.95	8647	168.00
4CX350FJ/8904	140.00	6156	110.00	8683	95.00
4CX600J/8809	835.00	6159	13.85	8877	465.00
4CX1000A/8168	242.50*	6159B	23.50	8908	13.00
4CX1000A/8168	485.00	6161	325.00	8950	13.00
4CX1500B/8660	555.00	6280	42.50	8930	137.00
4CX5000A/8170	1100.00	6291	180.00	6L6 Metal	25.00
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4CW800F	710.00	6360/A	5.75	6CL6	3.50
4D32	240.00	6399	540.00	6DJ8	2.50
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MOTOROLA	4884863B01	11.7MHz 2pole 15KHz bandwidth	5.00
PTI	5350C	12MHz 2pole 15KHz bandwidth	5.00
PTI	5426C	21.4MHz 2pole 15KHz bandwidth	5.00
PTI	1479	10.7MHz 8pole bandwidth 7.5KHz at 3dB, 5KHz at 6dB	20.00
COMTECH	A10300	45MHz 2pole 15KHz bandwidth	6.00
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	CFW455D	455KHz +-10KHz at 6dB , +-20KHz at 40dB	2.90
	CFW455H	455KHz +-3KHz at 6dB , +-9KHz at 40dB	2.90
	SFB455D	455KHz	2.50
	SFD455D	455KHz +-2KHz , 3dB bandwidth 4.5KHz +-1KHz	5.00
	SFE10.7MA	10.7MHz 280KHz +-50KHz at 3dB , 650KHz at 20dB	2.50
	SFE10.7MS	10,7MHz 230KHz +-50KHz at 3dB , 570KHz at 20dB	2.50
	SFG10.7MA	10.7MHz	10.00
NIPPON	LF-B4/CFU455I	455KHz +-1KHz	2.90
	LF-B6/CFU455H	455KHz +-1KHz	2.90
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2N4427	1.25
2N4428	1.85
2N4430	11.80
2N4927	3.90
2N4957	3.45
2N4959	2.30
2N5016	18.40
2N5026	15.00
2N5070	18.40
2N5090	13.80
2N5108	3.45
2N5109	1.70
2N5160	3.45
2N5177	21.62
2N5179	1.04
2N5216	56.00
2N5470	75.00
2N5583	3.45
2N5589	9.77
2N5590	10.92
2N5591	13.80
2N5596	99.00
2N5636	12.00
2N5637	15.50
2N5641	12.42
2N5642	14.03
2N5643	25.50
2N5645	13.80
2N5646	20.70
2N5651	11.05
2N5691	18.00
2N5764	27.00
2N5836	3.45
2N5842	8.45
2N5847	19.90
2N5849	20.00
2N5913	3.25
2N5916	36.00

TYPE	PRICE
2N5920	$ 70.00
2N5921	80.00
2N5922	10.00
2N5923	25.00
2N5941	23.00
2N5942	40.00
2N5944	10.35
2N5945	10.00
2N5946	12.00
2N5947	9.20
2N6080	6.00
2N6081	7.00
2N6082	9.00
2N6083	9.50
2N6084	12.00
2N6094	11.00
2N6095	12.00
2N6096	16.10
2N6097	20.70
2N6105	21.00
2N6136	21.85
2N6166	40.24
2N6267	142.00
2N6304	1.50
2N6368	30.00
2N6439	55.31
2N6459	18.00
2N6567	10.06
2N6603	13.50
2N6604	13.50
2N6679	44.00
2N6680	80.00
021-1	15.00
01-80703T4	65.00
35C05	15.00
102-1	28.00
103-1	28.00
103-2	28.00
104P1	18.00
163P1	10.00
181-3	15.00
210-2	10.00
269-1	18.00
281-1	15.00
282-1	30.00
482	7.50
564-1	25.00
698-3	15.00
703-1	15.00
704	4.00
709-2	11.00
711	4.00
733-2	15.00
798-2	25.00
3421	28.00
3683P1	15.00
3992	25.00
4164P1	15.00
4243P1	28.00
4340P3	18.00
4387P1	27.50
7104-1	28.00
7249-2	10.50
7283-1	37.50
7536-1	30.00
7794-1	10.50
7795	15.00
7795-1	15.00
7796-1	24.00
7797-1	36.00
40081 RCA	5.00
40279 RCA	10.00
40280 RCA	4.62
40281 RCA	10.00
40282 RCA	20.00
40290 RCA	2.80
40292 RCA	13.05
40294 RCA	2.50
40341 RCA	21.00

TYPE	PRICE
40608 RCA	$ 2.48
40673 RCA	2.50
40894 RCA	1.00
60247 RCA	25.00
61206 RCA	100.00
62800A RCA	60.00
62803 RCA	100.00
430414/3990RCA	50.00
3457159 RCA	20.00
3729685-2 RCA	75.00
3729701-2 RCA	50.00
3753883 RCA	50.00
615467-902	25.00
615467-903	40.00
2SC568	2.50
2SC703	36.00
2SC756A	7.50
2SC781	2.80
2SC1018	1.00
2SC1042	24.00
2SC1070	2.50
2SC1216	2.50
2SC1239	2.50
2SC1251	24.00
2SC1306	2.90
2SC1307	5.50
2SC1424	2.80
2SC1600	5.00
2SC1678	2.00
2SC1729	32.40
2SC1760	1.50
2SC1909	4.00
2SC1945	10.00
2SC1946	40.00
2SC1947	10.00
2SC1970	2.50
2SC1974	4.00
2SC2166	5.50
2SC2237	32.00
2SC2695	47.00
A2X1698	POR
A3-12	14.45
A50-12	24.00
A209	10.00
A283	6.00
A283B	6.00
A1610	19.00
AF102	2.50
AFY12	2.50
AR7115	20.00
AT41435-5	6.35
B2-8Z	10.70
B3-12	10.85
B12-12	15.70
BAL0204125	152.95
BF25-35	56.25
B40-12	19.25
B70-12	55.00
BF272A	2.50
BFQ85	2.50
BFR21	2.50
BFR90	1.00
BFR91	1.65
BFR99	2.50
BFT12	2.50
BFW16A	2.50
BFW17	2.50
BFW92	1.50
BFX44	2.50
BFX48	2.50
BFX65	2.50
BFX84	2.50
BFX85	2.50
BFX86	2.50
BFX89	1.00
BFY11	2.50
BFY18	2.50
BFY19	2.50
BFY39	2.50

TYPE	PRICE
BFY90	$ 1.50
BLW60C5	15.00
BLX67	12.25
BLX67C3	12.25
BLX93C3	22.21
BLY87A	7.50
BLY88C3	13.08
BLY89C	13.00
BLY90	45.00
BLY92	13.30
BLY94C	45.00
BLY351	10.00
BLY568C/CF	30.00
C2M70-28R	92.70
C25-28	57.00
C4005	2.50
CD1659	20.00
CD1899	20.00
CD1920	10.00
CD2188	18.00
CD2545	24.00
CD2664A	16.00
CD3167	92.70
CD3353	95.00
CD3435	26.30
CD3900	152.95
CM25-12	20.00
CM40-12	27.90
CM40-28	56.90
CME50-12	30.00
CTC2001	42.00
CTC2005	55.00
CTC3005	70.00
CTC3460	20.00
DV2820S	25.00
DXL1003P70	22.00
DXL2001P70	19.00
DXL2002P70	14.00
DXL3501AP100F	47.00
EFJ4015	12.00
EFJ4017	24.00
EFJ4021	24.00
EFJ4026	35.00
EN15745	20.00
FJ9540	16.00
FSX52WF	58.00
G65739	25.00
G65386	25.00
GM0290A	2.50
HEP76	4.95
HEPS3002	11.40
HEPS3003	30.00
HEPS3005	10.00
HEPS3006	19.90
HEPS3007	25.00
HEPS3010	11.34
HF8003	10.00
HFET2204	112.00
HP35821	38.00
HP35826B	32.00
HP35826E	32.00
HP35831E	30.00
HP35832E	50.00
HP35833E	50.00
HP35859E	75.00
HP35866E	44.00
HXTR2101	44.00
HXTR3101	7.00
HXTR5101	31.00
HXTR6104	68.00
HXTR6105	31.00
HXTR6106	33.00
J310	1.00
JO2000	10.00
JO2001	25.00
JO4045	24.00
KD5522	25.00
KJ5522	25.00
M1106	13.75

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RF TRANSISTORS (CONTINUED)

M1107	$16.75	MRF458	$20.70	NE02160ER	$100.00	SD1009	$15.00
M1131	5.15	MRF464	25.30	NE021350	5.30	SD1009-2	15.00
M1132	7.25	MRF466	18.97	NE13783	61.00	SD1012	10.00
M1134	13.40	MRF472	1.50	NE21889	43.00	SD1012-3	10.00
M9116	29.10	MRF475	3.10	NE57835	5.70	SD1012-5	10.00
M9579	6.00	MRF476	3.16	NE64360ER-A	100.00	SD1013	10.00
M9580	7.95	MRF477	20.00	NE64480 (B)	94.00	SD1013-3	10.00
M9587	7.00	MRF479	8.05	NE73436	2.50	SD1013-7	10.00
M9588	5.20	MRF492	23.00	NE77362ER	100.00	SD1016	15.00
M9622	5.95	MRF502	1.04	NE98260ER	100.00	SD1016-5	15.00
M9623	7.95	MRF503	6.00	PRT8637	25.00	SD1018-4	13.00
M9624	9.95	MRF504	7.00	PT3127A	5.00	SD1018-6	13.00
M9625	15.95	MRF509	5.00	PT3127B	5.00	SD1018-7	13.00
M9630	14.00	MRF511	10.69	PT3127C	20.00	SD1018-15	13.00
M9740	27.90	MRF515	2.00	PT3127D	20.00	SD1020-5	10.00
M9741	27.90	MRF517	2.00	PT3127E	20.00	SD1028	15.00
M9755	16.00	MRF525	3.45	PT3190	20.00	SD1030	12.00
M9780	5.50	MRF559	1.76	PT3194	20.00	SD1030-2	12.00
M9827	11.00	MRF587	11.00	PT3195	20.00	SD1040	5.00
M9848	35.00	MRF605	20.00	PT3537	7.80	SD1040-2	20.00
M9850	13.50	MRF618	25.00	PT4166E	20.00	SD1040-4	10.00
M9851	20.00	MRF626	12.00	PT4176D	25.00	SD1040-6	5.00
M9860	8.25	MRF628	8.65	PT4186B	5.00	SD1043	12.00
M9887	2.80	MRF629	3.45	PT4209	25.00	SD1043-1	10.00
M9908	6.95	MRF641	25.30	PT4209C/5645	25.00	SD1045	3.75
M9965	12.00	MRF644	27.60	PT4556	24.60	SD1049-1	2.00
MM1500	25.00	MRF646	29.90	PT4570	7.50	SD1053	4.00
MM1550	10.00	MRF648	33.35	PT4577	20.00	SD1057	10.00
MM1552	50.00	MRF816	15.00	PT4590	5.00	SD1065	4.75
MM1553	50.00	MRF823	20.00	PT4612	20.00	SD1068	15.00
MM1607	8.45	MRF846	44.85	PT4628	20.00	SD1074-2	18.00
MM1614	10.00	MRF892	35.50	PT4640	20.00	SD1074-4	28.00
MM1810	15.00	MRF894	46.00	PT4642	20.00	SD1074-5	28.00
MM1810	15.00	MRF901 3 Lead	1.00	PT5632	4.70	SD1076	18.50
MM1943	1.80	MRF901 4 Lead	2.00	PT5749	25.00	SD1077	4.00
MM2608	5.00	MRF902/2N6603JAN	15.00	PT6612	25.00	SD1077-4	4.00
MM3375A	17.10	MRF902B	18.40	PT6619	20.00	SD1077-6	4.00
MM4429	10.00	MRF904	2.30	PT6708	25.00	SD1078-6	24.00
MM8000	1.15	MRF905	2.55	PT6709	25.00	SD1080-7	7.50
MM8006	2.30	MRF911	2.50	PT6720	25.00	SD1080-8	6.00
MM8011	25.00	MRF965	2.55	PT8510	15.00	SD1080-9	3.00
MPSU31	1.01	MRF966	3.55	PT8524	25.00	SD1084	8.00
MRA2023-1.5	42.50	MRF1000MA	32.77	PT8609	25.00	SD1087	15.00
MRF134	10.50	MRF1004M	31.05	PT8633	25.00	SD1088	22.00
MRF136	16.00	MRF2001	41.74	PT8639	25.00	SD1088-8	22.00
MRF171	35.00	MRF2005	54.97	PT8659	25.00	SD1089-5	15.00
MRF208	11.50	MRF5176	24.00	PT8679	25.00	SD1090	15.00
MRF212	16.10	MRF8004	2.10	PT8708	20.00	SD1094	15.00
MRF221	10.00	MSC1720-12	225.00	PT8709	20.00	SD1095	15.00
MRF223	13.00	MSC1821-3	125.00	PT8727	29.00	SD1098-1	30.00
MRF224	13.50	MSC1821-10	225.00	PT8731	25.00	SD1100	5.00
MRF227	3.45	MSC2001	30.00	PT8742	19.10	SD1109	18.00
MRF230	2.00	MSC2010	93.00	PT8787	25.00	SD1115-2	7.50
MRF231	10.00	MSC2223-10	245.00	PT8828	25.00	SD1115-3	7.50
MRF232	12.07	MSC2302	POR	PT9700	25.00	SD1115-7	2.10
MRF237	3.15	MSC3000	35.00	PT9702	25.00	SD1116	5.00
MRF238	13.80	MSC3001	38.00	PT9783	16.50	SD1118	22.00
MRF239	17.25	MSC72002	POR	PT9784	32.70	SD1119	5.00
MRF245	35.65	MSC73001	POR	PT9790	56.00	SD1124	50.00
MRF247	31.00	MSC80064	35.00	PT31083	20.00	SD1132-1	15.00
MRF304	36.00	MSC80091	10.00	PT31962	20.00	SD1132-4	12.00
MRF306	50.00	MSC80099	3.00	PTX6680	20.00	SD1133	9.50
MRF313	11.15	MSC80593	POR	RE3754	25.00	SD1133-1	10.00
MRF314	29.21	MSC80758	POR	RE3789	25.00	SD1134-1	2.50
MRF315	28.86	MSC82001	33.00	RF35	16.00	SD1134-4	12.00
MRF316	55.43	MSC82014	33.00	RF85	17.50	SD1134-17	12.00
MRF317	63.94	MSC82020M	130.00	RF110	21.00	SD1135	10.25
MRF412	18.00	MSC82030	33.00	S50-12	23.80	SD1135-3	12.00
MRF420	20.12	MSC83001	40.00	S3006	15.00	SD1136	12.50
MRF421	25.00	MSC83003	82.00	S3007	10.00	SD1136-2	12.50
MRF422	38.00	MSC83005	70.00	S3031	22.00	SD1143-1	10.00
MRF427	17.25	MSC83026	POR	SCA3522	5.00	SD1143-3	17.00
MRF428	63.00	MSC83303	POR	SCA3523	5.00	SD1144	4.00
MRF433	12.07	MSC84900	60.00	SD345	5.00	SD1145-5	15.00
MRF449/A	12.65	MT4150	14.40	SD445	5.00	SD1146	15.00
MRF450/A	14.37	MT5126	25.00	SD1004	15.00	SD1147	15.00
MRF452/A	17.00	MT5596(2N)	99.00	SD1007	15.00	SD1188	10.00
MRF453/A	18.40	MT5768(2N)	95.00	SD1007-2	15.00	SD1189	24.00
MRF454/A	20.12	MT8762	25.00	SD1007-4	15.00	SD1200	1.50
MRF455/A	16.00	NE02136	2.00	SD1007-5	15.00	SD1201-2	15.00

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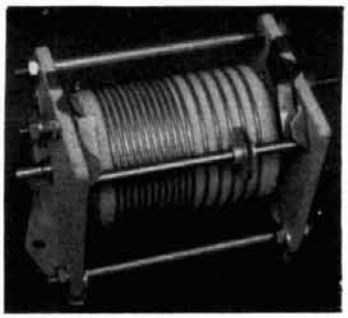
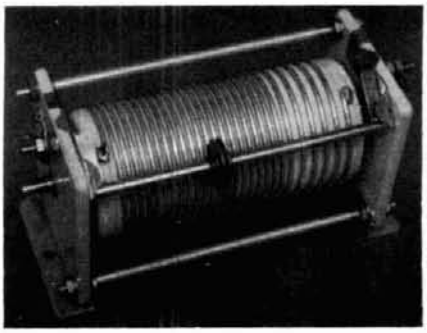
More Details? CHECK—OFF Page 160

E.F. JOHNSON ROLLER INDUCTORS



MODEL 229-0201-01
10UH at 3AMPS MAX. $36.99



MODEL 229-0202-01
18UH at 5AMPS MAX. $44.99

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UNELCO,SEMCO,ARCO METAL CLAD MICA CAPACITORS

Standard Size					Micro Size	
3.9	14	33	62	175	5	25
4.7	15	34	68	180	6	27
5	18	36	75	200	7	33
5.1	20	38	80	220	8	36
6.8	22	39	82	240	9	51
7	24	40	100	250	12	62
8.2	25	43	110	300	15	
9.1	27	44	120	360	16	
10	27.5	47	123	470	18	
11	28	50	125	500	20	
12	30	51	140	820	22	
13	32	56	150	1000	24	

********NOTE ALL VALUES LISTED IN PICO FARAD********

PRICE INFORMATION
1 to 10 $ .90ea. 11 to 51 $.80ea. 52 to 102 $.70ea.
103 and up call

****

GOULD NI-CAD BATTERIES

AA size 1.25v at 500mahr	new	a	$ 1.99
D size 1.25v at 4 AMPHR	new	h	7.49

GENERAL ELECTRIC NI-CAD BATTERIES

AA size 1.25v at 500mahr	new	a	2.99
195194 3.75v at 100mahr	new		1.99
AA size 3.75v at 100mahr	new	a	2.99
AA size pack of 10 12.5v at 450mahr	used	a	5.99
Sub C Pack of 10 12.5v at 2.5Amphr	new	c	9.99

UNION CARBIDE NI-CAD BATTERIES

193817 3.75v at 225mahr	new	a	2.99

GLOBE GEL-CELL BATTERIES

2v at 8AMPHR GC280	new	g	5.99
12v at 20AMPHR GC12200	new	g	49.99
12v at 23AMPHR GC12300	new	g	54.99

EAGLE PICHER GEL-CELL BATTERIES

12v at 1.5AMPHR CF12V1.5	new	d	11.99

GATES SEALED RECHARGEABLE LEAD ACID BATTERIES AND PACKS

2v at 2.5AMPHR D Cell	new	b	5.99
8v at 5AMPHR 4 X Cell	used	f	14.99
12v at 2.5AMPHR 6 D Cells	new	f	24.99
18v at 2.5AMPHR 9 D Cells	new	f	29.99

GENERAL ELECTRIC SEALED REACHARABLE LEAD ACID BATTERIES AND PACKS

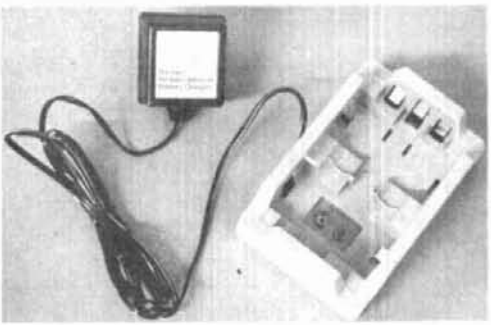
6v at 2.5AMPHR 3 D Cells	used	e	10.00
12v at 2.5AMPHR 6 D Cells	used	e	19.99
12v at 5AMPHR 6 X Cells	used	e	24.99

****

NI-CAD BATTERY CHARGERS

UNIVERSAL CHARGER $19.99

MALLORY CHARGER $23.99



EVEREADY CHARGER $9.99

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RF Transistors (continued)

SD1202	$10.00	SD1304-8	$ 2.50	SD1451-2	$15.00	SRF1427	$50.00	SD1244812	25.00	SD1410-8	21.00	SD1536-1	41.00	SRF2917	15.00
SD1212-8	4.95	SD1305	3.00	SD1452	20.00	SRF1431	40.00	SD1262	15.00	SD1413-1	18.00	SD1539H	100.00	SRF2918	15.00
SD1212-11	4.95	SD1307	3.00	SD1452-4	24.00	SRF1834	40.00	SD1263	15.00	SD1416	28.00	SD1542H1	170.00	SRF2919	15.00
SD1212-16	4.95	SD1308	3.00	SD1453H1	20.00	SRF2053-3	80.00	SD1263-1	15.00	SD1422-2	24.00	SD1544	26.00	SRF3071PF	50.00
SD1214-7	5.00	SD1311	1.00	SD1454-1	48.00	SRF2092	50.00	SD1272	10.95	SD1428	24.00	SD1545	33.00	SS4006	25.00
SD1214-11	5.00	SD1317	8.00	SD1477	35.00	SRF2147	22.00	SD1272-1	10.95	SD1428- 6084	12.00	SD1546H1	55.00	SS4152	15.00
SD1216	12.00	SD1319	2.50	SD1478	21.00	SRF2225	15.00	SD1272-2	10.95	SD1429-2	15.00	SD1561	79.00	TA7686	15.00
SD1219-4	15.00	SD1345-6	5.00	SD1480	93.00	SRF2264	25.00	SD1272-4	10.95	SD1429-3	14.90	SD1574-1	6.95	TA8559	15.00
SD1219-5	15.00	SD1347-1	1.00	SD1484	1.50	SRF2265	100.00	SD1278	13.75	SD1429-5	15.00	SD1575	6.95	TA8561	15.00
SD1219-8	15.00	SD1365-1	2.50	SD1484-5	1.50	SRF2281	5.00	SD1278-1	13.75	SD1430	12.00	SF4557	25.00	TA8562	15.00
SD1220	8.00	SD1365-5	2.50	SD1484-6	1.50	SRF2371	15.00	SD1278-5	13.75	SD1430-2	18.00	SK3048	5.00	TA8563	15.00
SD1220-1	9.50	SD1375	2.50	SD1484-7	1.50	SRF2347	50.00	SD1279-1	18.00	SD1434	28.00	SL501-59	15.00	TA8564	15.00
SD1220-9	8.00	SD1375-6	2.50	SD1488	22.85	SRF2356	38.00	SD1279-3	18.00	SD1434-5	28.00	SL501-173	15.00	TA8894	15.00
SD1222-8	16.00	SD1379	15.00	SD1488-1	28.00	SRF2378	16.00	SD1281-2	8.00	SD1434-9	28.00	SM7114	5.00	TI5189	3.55
SD1222-11	7.50	SD1380-1	1.00	SD1488-7	27.00	SRF2572	25.00	SD1283	10.00	SD1438	26.00	SRF112	15.00	TP312	2.50
SD1224-10	18.00	SD1380-3	1.00	SD1488-8	28.00	SRF2584	40.00	SD1283-2	10.60	SD1441	56.00	SRF395	50.00	TP1014	5.00
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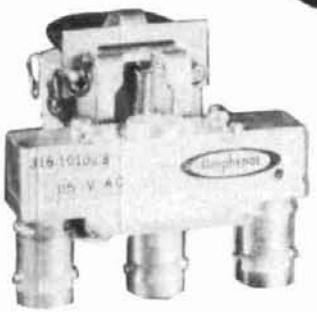

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NEW JERSEY: The Delaware Valley Radio Association's 13th annual Amateur Radio and computer equipment flea market, Sunday, March 17, 8 AM to 4 PM, New Jersey National Guard 112th Field Artillery Armory, Eggerts Crossing Road, Lawrence Township, Trenton. Advance registration $2.50, $3.00 at the door. Indoor and outdoor flea market area, dealers, and refreshments. Sellers bring own tables. Talk in on 146.52 and 146.07-.67 repeater. For tickets and space reservations: KB2ZY, Box 441B, RD#1, Stockton, NJ 08559. Please SASE.

ILLINOIS: LAMARSFEST '85 sponsored by the Libertyville and Mundelein Amateur Radio Society, Sunday, March 31, Lake County Fairgrounds, Grayslake. Doors open 8 AM. Set up 6 AM. Advance admission $2.00. $3.00 at the door. Indoor exhibits, code speed efficiency testing, free parking. Talk in on 146.94 simplex — 147.63-03 Waukegan Repeater. For information and reservations: LAMARS, Box 751, Libertyville, IL 60048.

ILLINOIS: The Sterling-Rockfalls Amateur Radio Society's Silver Anniversary Hamfest, March 10, Sterling High School Fieldhouse, 1608 4th Avenue, Sterling. Commercial distributors, dealers, free parking and a large flea market. Space for self-contained RV's overnight. Advance tickets $2.00. At door $3.00. Tables requiring electricity and all commercial tables $5.00. Others $3.00. For tickets, tables or information: Sue Peters, KA9GNR, PO Box 521, Sterling, IL 61081. (815) 625-9262. Talk in W9MEP 146.25/85.

OHIO: The Lake County Amateur Radio Association's seventh annual Lake County Hamfest and Computerfest, Sunday, March 31, Madison High School, Madison. 8 AM to 4 PM. Exhibitors 5:30 AM. Admission $3.00 advance and $3.50 at the door. Table and display space $5.00/6' table; $6.50/8' table. Plenty of free parking and all display space is indoors. Talk in on 147.81/.21. For information/reservations: SASE to Lake County Hamfest Committee, 713 W. Jackson, Painesville, Ohio 44077. (216) 952-9784.

INDIANA: The Indiana Hamfest (formerly the Martinsville Hamfest) sponsored by the Morgan County Repeater Association will be held March 10 at the Indiana State Fairgrounds Pavillion Building, Indianapolis. Admission $5.00 at the door. Premium table $40.00. Flea market table $8.00. Flea market space only $3.00. All tables by advance reservation only. Reserved table setup Saturday, March 9 from 3 to 9 PM. Space setup Sunday, March 10, 6 to 8 AM. Free parking. Talk in on 145.25. For table reservation or information SASE before March 1 to Aileen Scales, KC9YA, 3142 Market Place, Bloomington, IN 47401. (812) 339-4446.

PENNSYLVANIA: The third annual Southern Alleghenies Hamfest, sponsored by the Bedford, Altoona, Somerset, PA and Cumberland, MD Amateur Radio Clubs and Blue Knob Repeater Association. Sunday, April 14, 7 AM to 4 PM, Bedford County Fairgrounds. Admission $3.00. Tables $5.00 each. Tailgating $2.00. Dealers' setup Saturday, April 13. Talk in on Bedford Repeaters 145.49/89, 444.2 + 5 MHz and 146.52 simplex. For information: Joel Cunard, KB3TR, RD 6, Box 104, Bedford, PA 15522. (814) 623-9697.

MASSACHUSETTS: The Wellesley Amateur Radio Society's annual Spring Auction, Saturday, March 30, Wellesley Hills First Congregational Church, 207 Washington Street, Wellesley Hills. Check-in starts 10 AM. Auction 11 AM. Commission 15% with $1 minimum and $30 maximum. Food and drink available. No admission charge and plenty of free parking. Talk in on 147.63/03. For information: Nels Anderson, K1JR, (617) 872-5259.

ILLINOIS: Computer Central. Show and Swap. Sunday, March 3, Rand Park Field House, 2025 Dempster, Des Plaines. Information (312) 940-7547.

CALIFORNIA: The Tri-County ARA in cooperation with the Greater Los Angeles AR Group will conduct Amateur Radio exams in Pomona, Saturday, March 2. Pre-registration is required by February 16, 1985. Send completed FCC form 610, a copy of Amateur Radio license and SASE to T.C.A.R.A., PO Box 142, Pomona, CA 91769.

ILLINOIS: The 19th annual Rock River ARC Hamfest, Sunday, March 31, Lee County 4-H Center. Doors open 8 AM. Advance ticket donation $2.00. $3.00 at gate. 8' tables $5.00. Inside flea market space $3.00. Lunch will be served. Camping space available at a nominal charge. Talk in on 146.37/97 and 444.700/449.700. For tickets, tables, space or information: Shirley Webb, KA9HGZ, 618 Orchard St., Dixon, IL 61021 (815) 284-3811. Advance tickets available until March 15.

NEW JERSEY: The Split Rock Amateur Radio Association's annual Ham Auction, March 8, VFW Post 3401, Tabor Road, Rt. 53, Morris Plains. Doors open 7 AM. Auction starts 8 AM. Plenty of free parking. For information: PO Box 3, Whippany, NJ 07981 or K2RF Repeater 146.385/146.985.

OHIO: The Cincinnati QCWA Chapter 9's annual banquet in conjunction with the OOTC and the Dayton Hamvention, Friday, April 26, 7:30 PM, Neils Heritage House, 2189 S. Dixie Drive. For reservation and tickets ($12.50 pp) contact: Bob Dingle, Sec/Treas., 657 Dell Ridge Drive, Dayton, Ohio 45429. (513) 299-7114.

NEW JERSEY: The Chestnut Ridge Radio Club's Ham Radio flea market, Saturday, March 30, Education Building, Saddle River Reformed Church, East Saddle River Road and Weiss Road, Upper Saddle River. Tables $10.00 for first. $5.00 each additional. No admission fee. For information: Jack Meagher, W2EHD, (201) 768-8360 or Roger Soderman, KW2U (201) 666-2430.

NEW HAMPSHIRE: The Interstate Repeater Society's annual Flea Market, Saturday, March 16, Lions Club, Lions Avenue, Hudson. Talk in on 146.25/85 and 146.52 simplex. For table reservations: Interstate Repeater Society, PO Box 693, Derry, NH 03038. Or call Dick, WB8YGR (603) 889-3479.

NORTH DAKOTA: The Red River Valley and N.D.S.U. ARC's present "Hobbie Hi Tech 85", a Ham Radio/Computer show and swap meet, March 30, 8 to 5, Army National Guard Armory at Hector Field, Fargo. Reserved tables: Commercial $20; non-commercial — full $5.00, 1/2 $3.00. FCC exams by pre-registration. Talk in on 16/76. For information: Tim Gooding, WD0GUR, Event Chairman, 1006 Sheyenne Street, West Fargo, ND or call (701) 282-6630.

MASSACHUSETTS: 19/79 ARA of Chelsea will hold its annual flea market, Sunday, March 24, 11 AM to 3 PM, Ryan Hall at Ireson Building, 493 Western Avenue (Route 107) Lynn. Sellers setup 10 AM no admission charge. General admission $1.00. Table $6.00 advance or $8.00 at the door. For table reservations send checks to 19/79 ARA, PO Box 171, Chelsea, MA 02150.

19/79 ARA is sponsoring all level FCC exams, Saturday, March 16, Ryan Hall, Ireson Building, 493 Western Avenue (Route 107) Lynn, MA, 10 AM to 1 PM. For General, Advanced and Extra send form 610 with check for $4.00 payable to ARRL/VEC, 30 days prior to exam to Ralph Gandolfo, KA1E, 18 Murdock Drive, Peabody, MA 01960. For Tech, same requirements but send check and form 610 to Bob Kalustian, WA1DVR, 36 Columbia Road, Arlington, MA 02174. Novice there is no fee and walk-ins will be accepted but prefer prior registration. Send to Bob Kalustian at above address.

NEW JERSEY: The Shore Points ARC invites everyone to Springfest '85, Saturday, March 30, Atlantic County 4-H Center, Egg Harbor City, about 15 miles west of Atlantic City, 9 AM to 2 PM.

OPERATING EVENTS

"Things to do..."

MARCH 23-25: B.A.R.T.G. Spring RTTY Contest, 0200 GMT Saturday, March 23 to 0200 GMT Monday, March 25. Total contest period is 48 hours but no more than 30 hours of operation is permitted. Bands: 3.5, 7.0, 14.0, 21.0 and 28 MHz. Messages will consist of Time GMT (must be full 4 figure group) RST and message number (must consist of 3 figure group and start with 001 for 1st contact). Send contest or check log to: Peter Adams, G6LZB, 464 Whippendell Road, Watford, Herts, England WD1 7PT.

APRIL 13-14: The USS Becuna, a World War II Submarine, and the USS Olympia, Admiral Dewey's flagship, will be on the air from 1300Z Saturday to 2000Z Sunday. For a beautiful certificate please send business size SASE to Olympia Radio Amateur Club, PO Box 928, Philadelphia, PA 19105.

THE GUERRI REPORT

Ernie Guerri W6MGI

In the late 1950's the aerospace industry began to implement the idea of using electronics to diagnose and recommend solutions to problems in complex aircraft and missile systems. Because the crew workload in the B58 jet bomber was so demanding, for example, recorded voice warnings were used to alert the pilot to failures in critical systems — engine fires, loss of hydraulic fluid pressure, and so on.

Although this type of non-human intervention is indeed useful, its success depends largely on the premise that design engineers can anticipate all critical failure modes. The fact that many systems experience failures suggests serious flaws in this premise.

A more useful method of fault location and correction would be a scheme that could "learn" the system of which it is a part, and then adapt its actions to respond to the status of the system elements. During the 1970's such methods were implemented using the processing power made possible by ICs and the beginnings of LSI. Termed "expert" systems because they could make rudimentary logical decisions about events that were not necessarily predetermined, such systems proved successful in "fault-tolerant" computers aboard spacecraft in which no repairs would be possible during the planned life of the craft.

In the 1980's, the advent of VLSI has enabled even more dramatic advances: the processing power now available allows the actualization of rudimentary "intelligent" systems. At this point a couple of clarifications are in order. *Intelligent,* in this context, refers to terrestrial carbon-based biological specimens, more specifically, average human intelligence. *Processing power* is a squishy term; Dick Morley, an expert in artificial intelligence, points out that a Cray supercomputer could just about manage the flight dynamics activities of a bumble bee's landing. It takes a lot of processing to handle even the relatively "routine" tasks we take for granted.

Today's intelligent systems generally have the ability to learn from experience — that is, make a statistical determination of the likelihood of subsequent events from a database of prior related events. During the rest of the 1980's we can expect to see increased application of artificial (electronic) intelligence to industrial processes, medical instrumentation, test equipment, and space exploration.

Around the corner — sometime in the 1990's — we will begin to see the first devices with enough processing power to perform actual *inference.* These will be machines with enough memory and sufficient logic to make judgments based on *their own* experience.

The Japanese ICOT supercomputer project is aimed in this general direction, and is expected to achieve its initial goals by the mid-1990's. Similar efforts are underway at several facilities in the United States. Further into the future, perhaps after the year 2000, we can expect to see machines with a greater capacity for inference than humans — probably based on speed and parallel logic — and with non-human logic and communication algorithmic approaches to problem solving. By about 2020 or 2030 we should have machines capable of experiencing emotion — although we may have difficulty recognizing it as such because of its radical divergence from human experience. Perhaps I should add that the machines may have difficulty understanding *our* emotions. Enter bionic shrinks!

The most fruitful applications for such extensive computing power are not yet clear. We must also develop the parallel dexterity which will enable these devices to perform useful work. Each step in the development process will have its advances and setbacks. However, it is nearly certain that we are on the threshold of extending our intelligence to entities capable of transcending our own abilities. We needn't view this prospect as the creation of competitors — or as some might, the creation of our future masters — but rather as an opportunity to expand our horizons.

It's nothing more — and nothing less.

ham radio

Food for thought.

Our new Universal Tone Encoder lends its versatility to all tastes. The menu includes all CTCSS, as well as Burst Tones, Touch Tones, and Test Tones. No counter or test equipment required to set frequency-just dial it in. While traveling, use it on your Amateur transceiver to access tone operated systems, or in your service van to check out your customers' repeaters; also, as a piece of test equipment to modulate your Service Monitor or signal generator. It can even operate off an internal nine volt battery, and is available for one day delivery, backed by our one year warranty.

- All tones in Group A and Group B are included.
- Output level flat to within 1.5db over entire range selected.
- Separate level adjust pots and output connections for each tone Group.
- Immune to RF
- Powered by 6-30vdc, unregulated at 8 ma.
- Low impedance, low distortion, adjustable sinewave output, 5v peak-to-peak
- Instant start-up.
- Off position for no tone output.
- Reverse polarity protection built-in.

Group A

67.0 XZ	91.5 ZZ	118.8 2B	156.7 5A
71.9 XA	94.8 ZA	123.0 3Z	162.2 5B
74.4 WA	97.4 ZB	127.3 3A	167.9 6Z
77.0 XB	100.0 1Z	131.8 3B	173.8 6A
79.7 SP	103.5 1A	136.5 4Z	179.9 6B
82.5 YZ	107.2 1B	141.3 4A	186.2 7Z
85.4 YA	110.9 2Z	146.2 4B	192.8 7A
88.5 YB	114.8 2A	151.4 5Z	203.5 M1

- Frequency accuracy, ± .1 Hz maximum - 40°C to + 85°C
- Frequencies to 250 Hz available on special order
- Continuous tone

Group B

TEST-TONES	TOUCH-TONES		BURST TONES			
600	697	1209	1600	1850	2150	2400
1000	770	1336	1650	1900	2200	2450
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2175	941	1633	1750	2000	2300	2550
2805			1800	2100	2350	

- Frequency accuracy, ± 1 Hz maximum - 40°C to + 85°C
- Tone length approximately 300 ms. May be lengthened, shortened or eliminated by changing value of resistor

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Limit 15 inquiries per request.

Please use before April 30, 1985.

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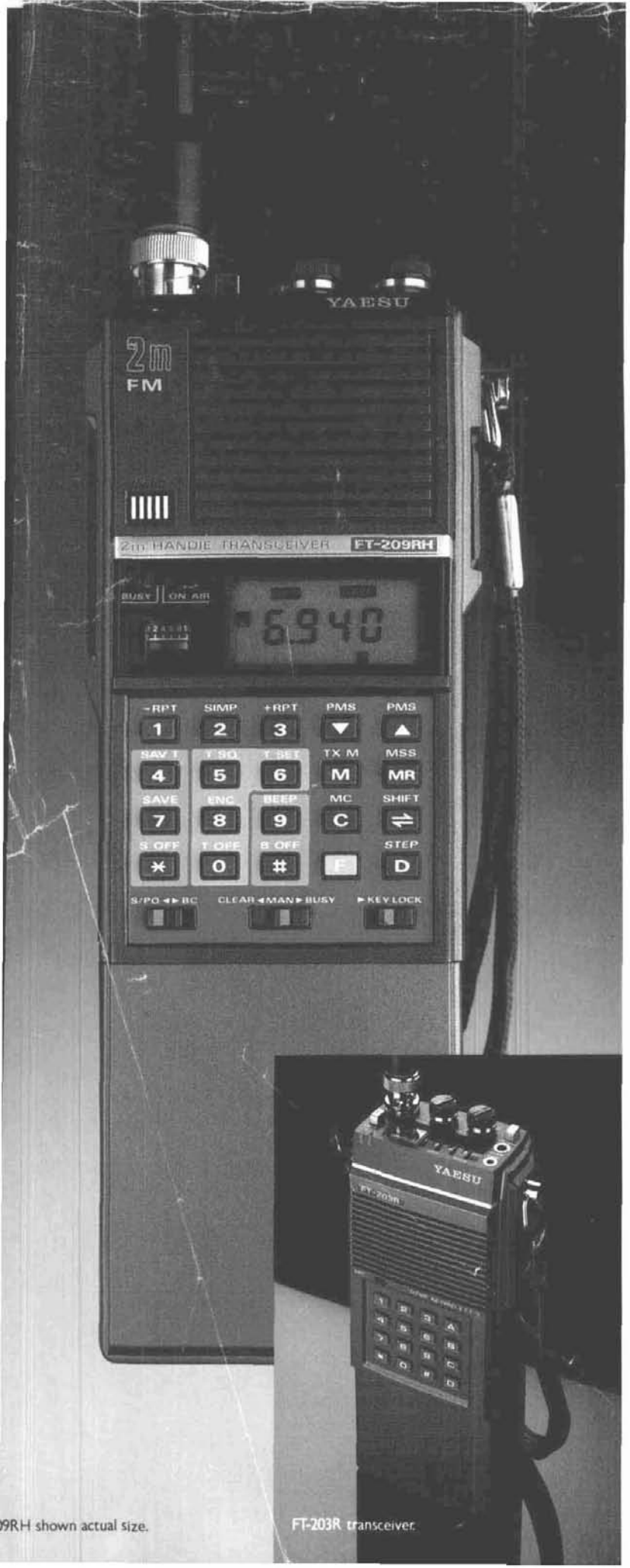

09RH shown actual size.

FT-203R transceiver.

The Yaesu FT-209RH. 5 watts that your batteries can live with.

Have the power you need when you need it with Yaesu's new 5-watt, 2-meter handheld. Power to get out in situations where ordinary HTs just won't make it.

We designed our HT with a unique user-programmable Power Saver that puts the rig to "sleep" while you're monitoring and "wakes it up" when the squelch breaks. So you can listen for hours and still have plenty of power to hit those hard-to-reach repeaters when you need to.

With the FT-209RH there's no need to fiddle with knobs when you change from one memory channel to another. That's because you can independently store everything you need in each of the ten memories: receive frequency, standard or non-standard offset, even tone encode/decode with an optional module. And then recall any channel at the touch of a button.

It's easy to hear what's happening on your favorite repeaters or simplex frequencies. Just touch a button and scan all memory channels, or selected ones. Or all frequencies between any two adjacent memories. Use the priority feature to return automatically to your special frequency when it becomes active.

Bring up controlled-access machines with the optional plug-in subaudible tone encoder/decoder, independently programmed from the keyboard for each channel. Listen for tone-encoded signals on selected channels—without having to hear a bunch of chatter—by enabling the decode function.

The FT-209RH, which covers 10 MHz for CAP and MARS use, comes complete with a 500-mAh battery, charger and soft case.

For those who want a basic radio without the bells and whistles, consider the compact, lightweight FT-203R. This economical HT features 2.5 watts of power and an optional DTMF keypad. Most all the accessories for the 209 work with the 203, including an optional VOX headset that gives you hands-free operation that's perfect for public service events.

So when you visit your dealer, let him know you won't settle for anything but the best. A radio built by Yaesu.

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9070 Gold Park Drive, Hamilton, OH
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Prices and specifications subject to

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Digital Code Squelch...

TR-2600A

Kenwood's TR-2600A introduces DCS (Digital Code Squelch) circuitry, a signaling concept developed by Kenwood. DCS allows each station to have its own "private call" code or to respond to a "group call" or "common call" code. There are 100,000 different 5-digit ASCII code combinations possible. You can program in call signs up to 6 digits in the ASCII code. When operating in the DCS mode, this information can then be automatically transmitted each time the transmit key is depressed. This revolutionary feature is only the beginning! The TR-2600A also sports a high impact plastic case, that is extra rugged and scuff-resistant. The molded-in color adds to the attractive appearance. The large L.C.D. display is easy to read in direct sunlight or in the dark with a convenient lamp switch. It displays transmit/receive frequencies, memory channels, and five arrow indicators for "F LOCK" frequency lock, "REV" repeater reverse, "PROG.S" programmed scan, "MS" memory scan, "ALERT.S" alert scan. A star indicates "MEMORY LOCK-OUT" is activated, and repeater offset indicated by "+, −, S and M." The TR-2600A has 10 memories, nine for simplex or transmit with frequency offset ±600 kHz and one (memory 0) for non-standard split frequencies. Memory scan and programmable band scan have the added convenience of "Time operated Resume" that stops on busy channel and holds for approximately 5 seconds, then resumes scanning, or "Carrier Operated Resume" that stops on busy channel and resumes when signal ceases.

Memory scan, scans only those memories in which data is stored, and memory lock-out allows you to skip selected memory channels without loss of data previously stored! Manual Scanning UP/DOWN in 5-kHz steps and programmable automatic band scan are also useful features. The TR-2600A has a built-in "S" meter on the top panel which also indicates battery level when in transmit mode. Extended frequency coverage, 142.000-148.995 MHz allows transmit capability in 5-kHz steps for simplex or repeater operation on most MARS and CAP frequencies. Receive frequency coverage includes 140.000-159.995 MHz.

These features only tell part of the story. The TR-2600A also has keyboard frequency selection, built-in 16-key autopatch encoder, "TX STOP" switch, HI (2.5)/LOW (300 mw) power switch, REV switch, "SLIDE-LOC" battery pack, high efficiency speaker, BNC antenna terminal, and all of this in an extremely compact and lightweight package!

Kenwood's TR-2600A, with D.C.S., leads the way in high technology handheld transceivers!

Optional accessories:

- TU-35B built-in programmable sub-tone encoder
- ST-2 Base Stand
- MS-1 Mobile Stand
- PB-26 Ni-Cd Battery
- DC-26 DC-DC Converter
- HMC-1 Headset with VOX
- SMC-30 Speaker Microphone
- LH-3 Deluxe Leather Case
- SC-9 Soft Case
- BT-3 AA Manganese/Alkaline Battery Case
- EB-3 External C Manganese/Alkaline Battery Case
- RA-3, 5. Telescoping Antenna
- CD-10 Call Sign Display

More information on the TR-2600A is available from authorized dealers of Trio-Kenwood Communications, 1111 West Walnut Street, Compton, CA 90220.

Specifications and prices are subject to change without notice or obligation.